MARYLAND GEOLOGICAL SURVEY

STATE OF MARYLAND
DEPARTMENT OF NATURAL RESOURCES

MARYLAND GEOLOGICAL SURVEY
KENNETH N. WEAVER, *Director*

BULLETIN 31

PART 1

HYDROLOGY OF CHANNEL-FILL DEPOSITS NEAR SALISBURY, MARYLAND AS DETERMINED BY A 30-DAY PUMPING TEST

by

FREDERICK K. MACK
and
WILBERT O. THOMAS, JR.

AND

PART 2

EXPLORATION AND MAPPING OF SALISBURY PALEOCHANNEL, WICOMICO COUNTY, MARYLAND

by

JAMES M. WEIGLE

Prepared in cooperation with the Geological Survey
United States Department of the Interior
and the
City of Salisbury

1972

PART 1

Contents

Illustrations

Tables

PART 2

Contents

Illustrations

Tables

BULLETIN 31

PART 1

HYDROLOGY OF CHANNEL-FILL DEPOSITS NEAR SALISBURY, MARYLAND AS DETERMINED BY A 30-DAY PUMPING TEST

by
FREDERICK K. MACK
and
WILBERT O. THOMAS, JR.
U. S. Geological Survey

ABSTRACT

The hydrologic characteristics of a very permeable sand and gravel aquifer filling a channel of uncertain origin were tested by pumping the aquifer at 4,000 gpm (gallons per minute) for 30 days. The aquifer 2½ miles north of the City of Salisbury, Maryland, was first discovered in 1962 and was partly explored by test drilling in 1963 and 1964.

Sediments filling the ancient river valley are of Pleistocene age and are as much as 220 feet thick at the pumping-test site. Geologic data indicate that the sediments are in three distinct layers, which have been designated as zones A, B, and C with increasing depth. Zone C, grading from fine-grained sediments at the base to coarser grained sediments at its top, the oldest of the three, is less permeable than the overlying zones. It is 30 to 50 feet thick and occurs at altitudes from 130 to 160 feet below sea level.

Zone B, the major source of water in the three zones, ranges in thickness from 0 to 80 feet. It is a long, narrow deposit of coarse sand and gravel occurring at altitudes from 50 to 130 feet below sea level. Zone A ranges in thickness from 50 to 90 feet. It is composed of coarse sand but contains some clay layers and is generally finer in character than zone B. It ranges in altitude from 40 feet above sea level to 50 feet below sea level.

Water levels, measured in 18 observation wells, declined throughout the 30-day period of pumping but the cone of depression probably reached a steady condition. The pumped well, Wi-Ce 200, had a drawdown of 24 feet and a specific capacity of 165 gpm per foot of drawdown after 30 days of pumping. The aquifer transmissivity is 400,000 gpd (gallons per day) per foot in the immediate vicinity of the pumping well. Artesian conditions existed during the early minutes of the test, but water-table conditions probably existed throughout most of the test.

Hydrographs for three stream-gaging stations on Little Burnt Branch show that streamflow increased by 2.1 cfs (cubic feet per second) in the downstream direction before pumping commenced, decreased in the downstream direction during the drawdown phase of the test by 1.2 cfs, and promptly returned to the original relationship of increasing flow downstream with termination of the pumping phase. Under natural (non-pumping) conditions, the aquifer in the vicinity of the pumping-test site discharges as much as 7 cfs of water to Little Burnt Branch and the North Prong of the Wicomico River. By the end of the drawdown phase of the test, the local hydrologic system had adjusted itself to the pumping of 4,000 gpm (8.9 cfs) by the diversion to the pumping well of (1) some water that had been discharging naturally to the nearby streams and (2) some water that was already in the streams.

ABSTRACT—Continued

The North Prong Wicomico River would serve as a reliable source of substantial recharge to the aquifer in the vicinity of the test site, if the aquifer were to be developed by heavy pumping. Other sites on the aquifer farther from streams do not have this advantage and must be expected to have lower capabilities. Prediction of the long-term yield of the aquifer would be hazardous on the basis of the 30-day test but its gradual development, accompanied by careful monitoring of ground-water levels, streamflow, and pumpage will undoubtedly reveal the availability of many millions of gallons of water per day.

The water pumped from the aquifer is a sodium bicarbonate type having a dissolved-solids content ranging from 42 to 52 mg/l (milligrams per liter). The most significant change noted during the test was a gradual decrease in the iron concentration from 0.46 mg/l prior to the test to 0.27 mg/l at the end of the 30-day pumping period.

Water in the streams during the test was slightly colored and contained concentrations of dissolved solids slightly higher than the ground water.

INTRODUCTION

This report describes the results of a 30-day test made to evaluate the ground-water potential of a very permeable sand and gravel aquifer 2½ miles north of Salisbury, Maryland. First evidence of the existence of the aquifer was obtained in 1962 during a cooperative study of the Salisbury area made by the U. S. Geological Survey, the Maryland Geological Survey, and the City of Salisbury. Test holes drilled in 1963 and 1964 to confirm its existence furnished much geologic data regarding its character and extent and indicated that it is a potential source of relatively large quantities of water (Hansen, 1966, and Boggess and Heidel, 1968). The possibility of using water from this aquifer to help satisfy rising demands for water required that tests be made to evaluate the resource. Information regarding the quantity and quality of water available was needed to plan for its proper use. The pumping test described in this report was made in response to these needs. The test showed the effects on ground-water levels and rates of streamflow in the area caused by pumping a well at the rate of 4,000 gpm. The quality of water in the aquifer was determined from samples collected during the test. This report describes the hydrologic setting, the test procedures and results, and a brief interpretation of the data obtained.

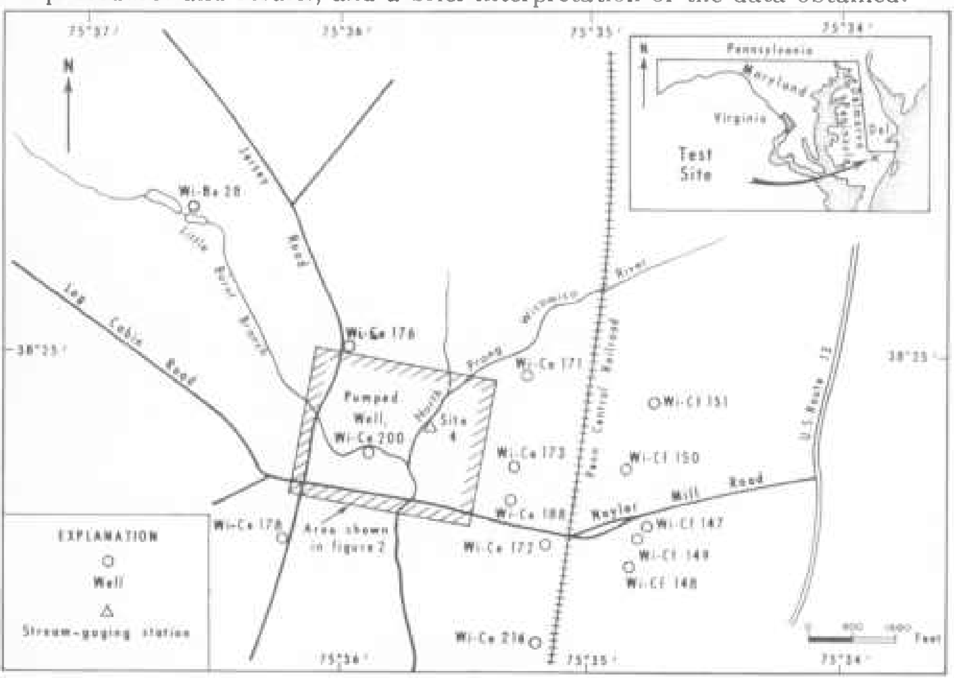


Figure 1. Map showing the location of the pumping-test site.

The site of the test is on the Delmarva Peninsula in the Coastal Plain of Maryland about 70 miles southeast of the Fall Line (fig. 1).

The pumping well was drilled about 100 feet south of Little Burnt Branch at an altitude of about 29 feet. Most observations during the test were made at points within half a mile of the pumping well (fig. 2), but two observation sites (wells Wi-Be 28 and Wi-Cf 147) were about 1.5 miles from the pumping well (fig. 1).

Valuable assistance was given by Mr. P. C. Cooper, Director, and Mr. Kenneth Haensler of the Department of Public Works of Salisbury, and by members of their staff. Funds for the construction of the large-capacity test well (Wi-Ce 200) were provided by the City of Salisbury. Contributors to early planning for the project were Durwood Boggess, Richard Gardner, and Patrick Walker of the U. S. Geological Survey.

GEOLOGIC SETTING

Unconsolidated coastal plain sediments at the test site are more than 5,000 feet thick. The sediments investigated in this study were (1) the Salisbury Formation[1] of Pleistocene age, which includes the channel-fill aquifer, and (2) the upper part of the underlying Miocene sediments, which includes the Manokin aquifer. Table 1 describes the lithologic and water-bearing characteristics of these units and shows their relationship to one another.

Results of earlier studies on the Salisbury Formation in this general area have been described by Rasmussen and Slaughter, 1955; Rasmussen and Andreasen, 1959; Hansen, 1966; and Boggess and Heidel, 1968. The last two studies indicated that an ancient river eroded a channel into the surface of the deposits of Miocene age during a period when sea level was much lower than it is now. The channel was later filled with alluvial sand and gravel of presumed Pleistocene age. Hansen (1966) used the term "paleochannel" to describe this geologic feature. The sand and gravel deposits filling the "paleochannel" are referred to as "channel-fill deposits" in this report. Part II of this report describes the extent, character, and thickness of these deposits as determined by test drilling.

[1]The term Salisbury Formation in this report refers to the same geologic unit described in the Maryland Geological Survey Report of Investigations No. 2 and does not imply conformance with stratigraphic nomenclature of the U. S. Geological Survey.

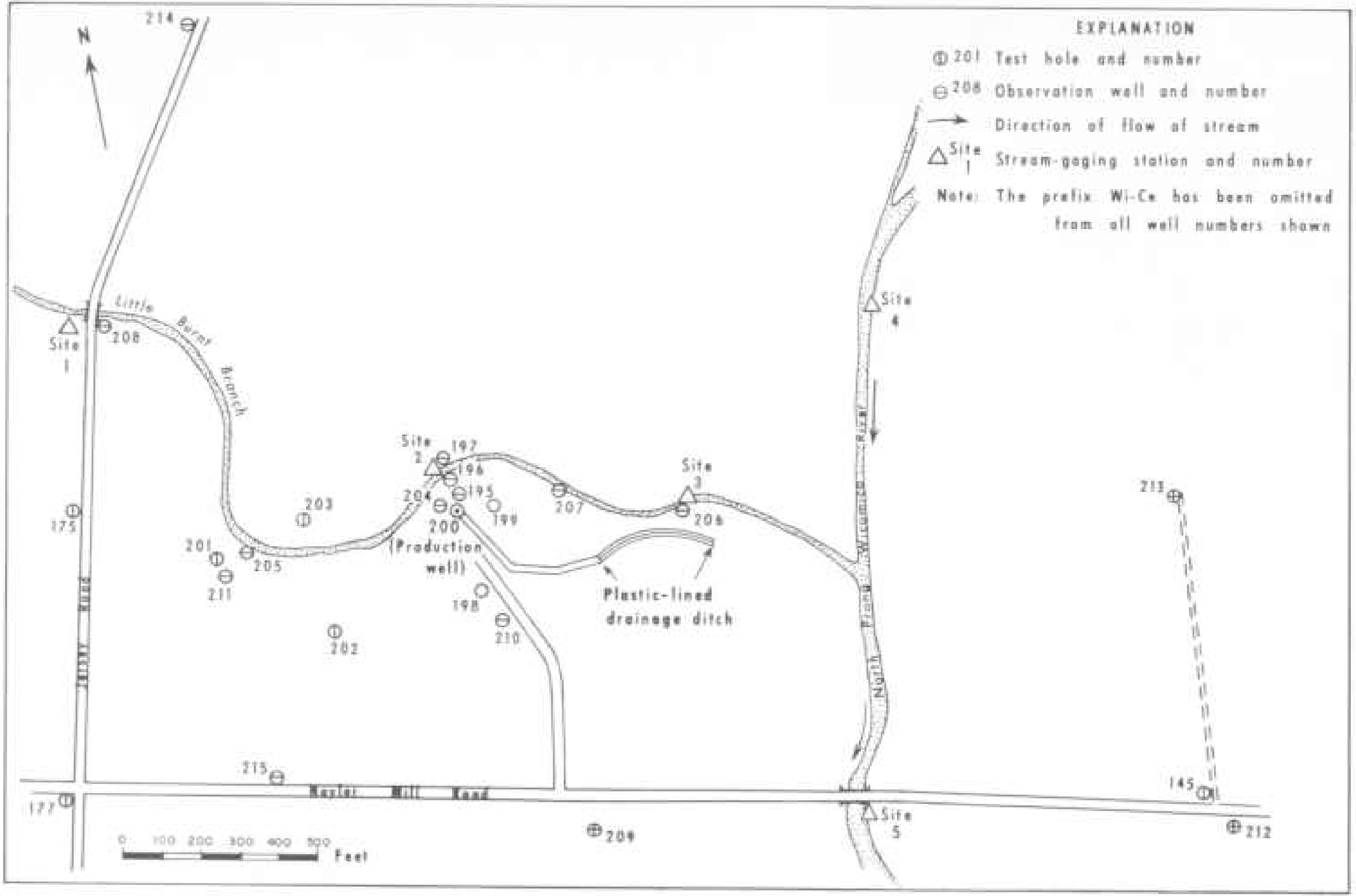


Figure 2. Map showing locations of data-collection stations in the vicinity of the pumping well.

TABLE 1. Geologic units at the pumping-test site and their lithologic and water-bearing characteristics.[1]

Series	Geologic unit		Hydrologic unit		Thickness (feet)	Lithologic character	Water-bearing characteristics
Holocene	....		....		0–3	Sand, fine-grained, tan; wind-blown material; mantles interfluvial areas. Gravel, sandy, gray to tan; fluvial deposits associated with present rivers. Clay, gray to black, occasionally peat-bearing;	....
Pleistocene	Walston silt		Aquiclude		0–20	Interbedded clay, sandy to silty and sand, fine-to medium-grained, very clayey, mottled gray to tan; tidal marsh deposit.	....
Pleistocene	Salisbury aquifer	Beaverdam sand	Aquifer	Zone A	50–90	Sand, coarse, brown, with some clay.	Capable of yielding large quantities of water but much more limited in water-yielding capability than Zone "B".[2]
Pleistocene	Salisbury aquifer	Red gravelly facies	Aquifer	Zone B	0–80	Sand, very coarse and gravel, tan.	Zone of highest permeability. Yielded 4,000 gpm for 30 days from one well during the test described by tbis report.
Pleistocene	Salisbury aquifer	Reworked Miocene(?)	Aquifer	Zone C	30–50	Sand, fine to coarse, with a few thin layers of clay, gray.	Capable of yielding moderate quantities but much more limited than zones "A" and "B".[2]
Miocene	Yorktown Formation		Lower aquiclude		0–80	Clay, silt, and sand, very fine to fine; dark gray; rarely fossiliferous.	Generally acts as an upper confining layer for tbe Manokin aquifer.
Miocene	Yorktown Formation		Manokin aquifer		100–130[3]	Sand, fine to coarse; gray.	Yields small to moderate quantities of water. Flowing wells frequently encountered at altitude less tban 25 feet above mean sea level.[2]
Miocene	St. Marys Formation		Aquiclude		70–140	Clay, "sticky", silt, and sand, very fine to fine; dark gray; very fossiliferous.	No water produced in area from these sediments. Acts as lower confining boundary of Manokin aquifer.

[1]Some geologic names used in this report do not conform to the stratigraphic nomenclature of tbe U. S. Geological Survey.
[2]Small indicates yields of 5-25 gpm; moderate, 25-300 gpm; large, over 300 gpm.
[3]Thinnner beneath the channel-till deposits.

Figure 3, based on the examination of drill cuttings and geophysical logs, is a geologic section showing how the channel-fill deposits occur with respect to the deposits of Miocene age. Criteria used in picking the contact between Pleistocene and Miocene deposits were: (1) the color change in the sediments from orange-brown to gray; (2) a significant decrease in median grain size; and (3) characteristic curves in geophysical logs of wells. The channel is shown to have been cut into the sands of the Manokin aquifer, an important artesian bed tapped by wells in Wicomico, Somerset, and Worcester Counties.

Hansen (1966) stated that the Salisbury Formation consists of two lithofacies, the Beaverdam sand and the red gravelly facies. However, at the pumping-test site, lithologic and geophysical logs indicate the existence of three distinct zones, A, B, and C. The channel-fill deposits are relatively permeable from their outcrop (30 to 40 feet above sea level) but, as may be seen in the classification below, zone B is unique because it is exceptionally permeable.

Zone	Lithology	Altitude in feet, related to mean sea level
A	Sand, coarse, brown, with some clay	+40 to —50
B	Sand, very coarse, and gravel, tan	—50 to —130
C	Sand, fine to coarse, with a few thin layers of gray clay	—130 to —160

The differences in the character of the zones are illustrated by the geophysical and lithologic logs for well Wi-Ce 204 shown in figure 4. The geophysical logs indicate that zone B, and, to a lesser extent, zone A, constitute the principal aquifer at the test site.

Figure 5, part A, is a map showing that the thickness of zone B ranges from 0 to more than 100 feet. Zone B is thickest in the deepest parts of the channel and its edges are truncated by the valley walls. Zone B, therefore, is a long narrow deposit, the ends of which have not yet been defined (see Part II).

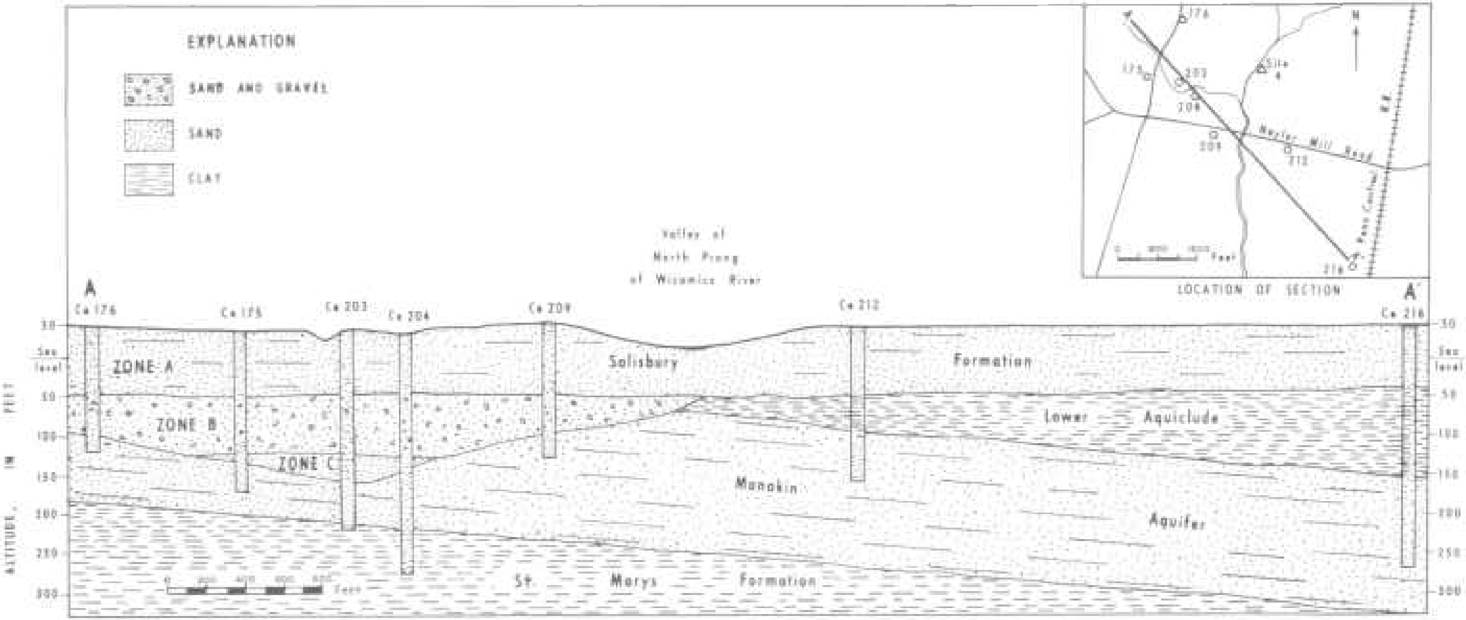


Figure 3. Geologic section showing how the channel-fill deposits occur with respect to the Miocene deposits.

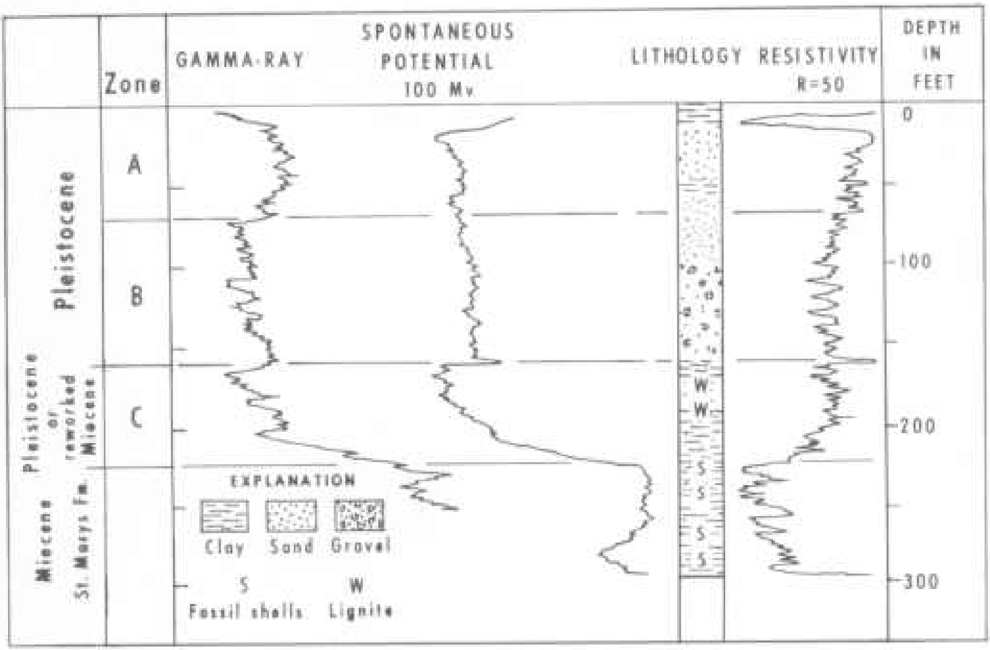


Figure 4. Geophysicol logs for well WI-Ce 204 showing the bosis for clossifying the chonnel-fill deposits by zones.

HYDROLOGIC SETTING

Streams near the test site were receding from unusually high stages when the drawdown phase of the test was started because exceptionally high precipitation (13.69 inches) occurred in the area during the previous month. Figure 6, the hydrograph for well Wi-Cf 147, about 1 mile east of the pumped well, shows that the pumping test was started at a time when ground-water levels were exceptionally high. Daily precipitation is plotted graphically in figure 23.

North Prong Wicomico River, with a mean annual discharge of 35 mgd (million gallons per day), crosses the aquifer about 1,000 feet east of the production well. (See fig. 5). Little Burnt Branch, with a flow seldom greater than 3 mgd flows into the larger stream where North Prong Wicomico River crosses the aquifer.

Under natural (nonpumping) conditions, the hydrologic setting of the pumping-test site is that of a dynamic system in which an aquifer is losing water by two processes:

1. By discharging some water directly into the nearby streams, Little Burnt Branch and North Prong Wicomico River.
2. By evapotranspiration.

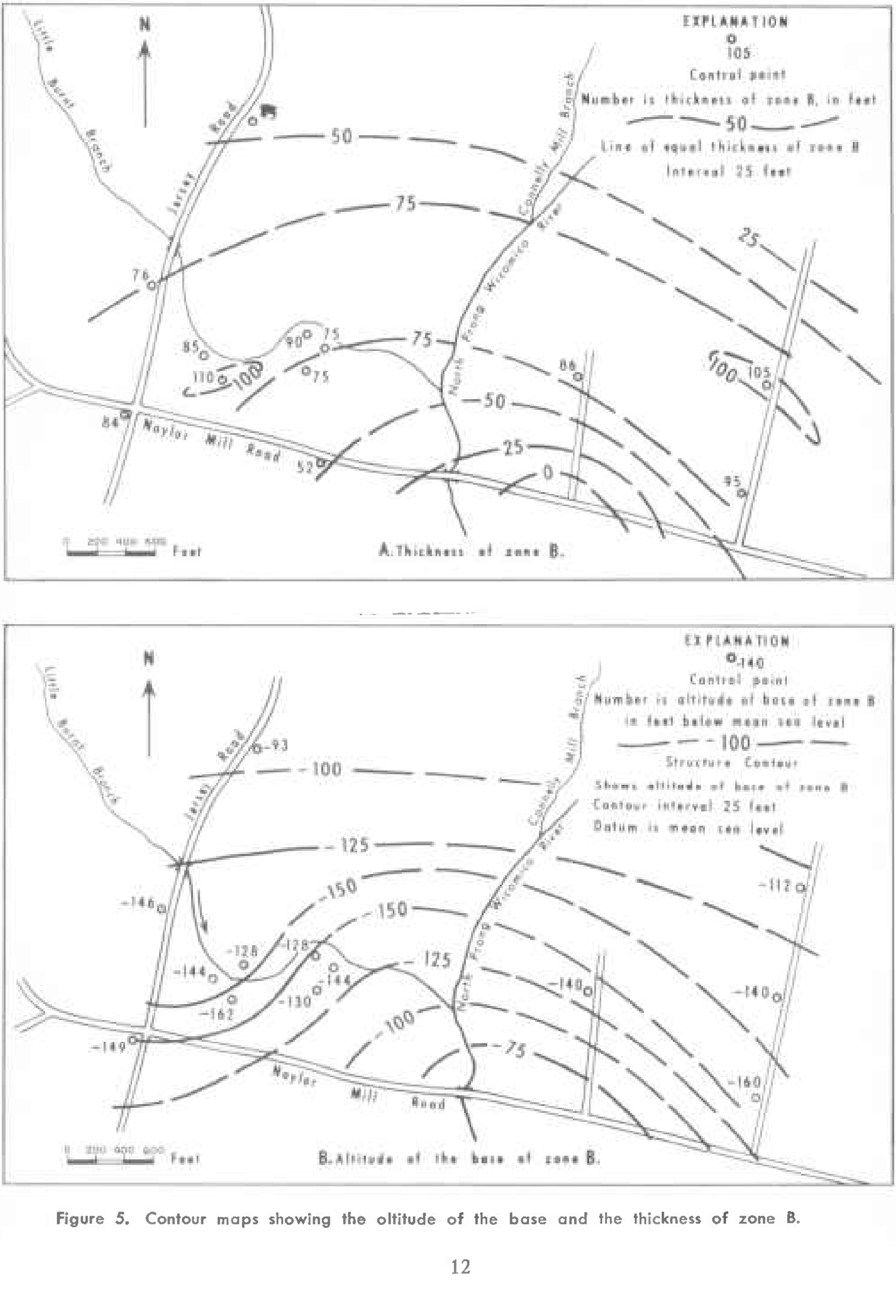


Figure 5. Contour maps showing the oltitude of the base and the thickness of zone B.

Most of the land surface in the area is a plain about 40 feet above sea level that is partly forested and partly cultivated, and with a water table about 20 feet above sea level. However, some rather deep gullies have been cut into the plain. One such gulley at the pumping-test site, the channel carrying the flow of Little Burnt Branch, has been cut to 3 or 4 feet below the water table to act as a drain. Thus, the pumping well is in the discharge area of a larger hydrologic system, and the reaches of Little Burnt Branch, Connelly Mill Branch, and North Prong Wicomico River, extending north from Naylor Mill Road, form what is virtually a high-capacity spring.

Data in table 2 and data presented by Boggess and Heidel (1968, p. 37 and 38) show that the amount of ground-water inflow is exceptionally great in the 4 miles of stream channel upstream from Naylor Mill Road. Gains in these reaches range from 11 cfs in dry seasons to 29 cfs in wet seasons. The gain in the reach was about 24 cfs on September 25, 1963, a time when the stream discharge at site 5 (see fig. 2) was similar to discharges during the pumping test. The reaches of North Prong, Connelly Mill Branch, and Little Burnt Branch extending about half a mile upstream from site 5 probably receive the largest percentage of the "gain" because the channel-fill deposits occur in that area.

Static water levels from observation wells tapping zone B were used to prepare figure 7, part A, a map showing the potentiometric

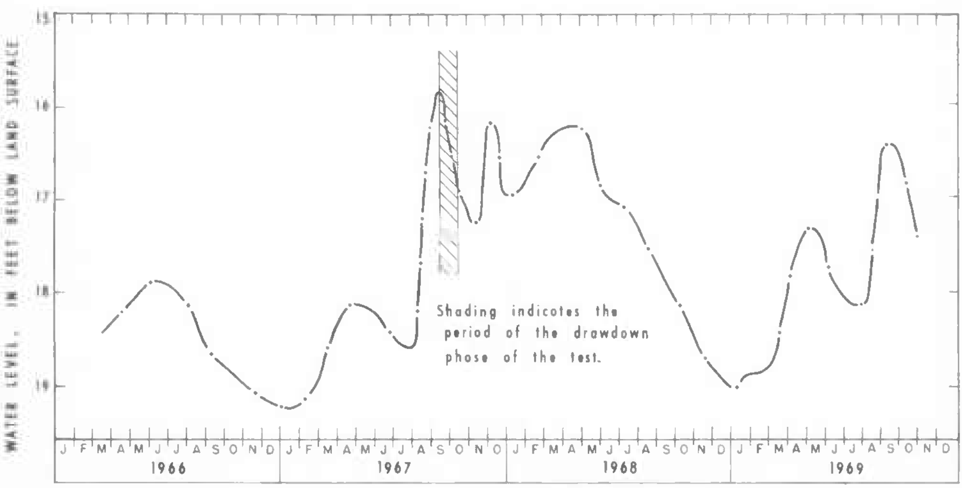


Figure 6. Hydrograph for observation well Wi-Cf 147 showing that water levels at the beginning of the test were near the maximum levels for the period of record.

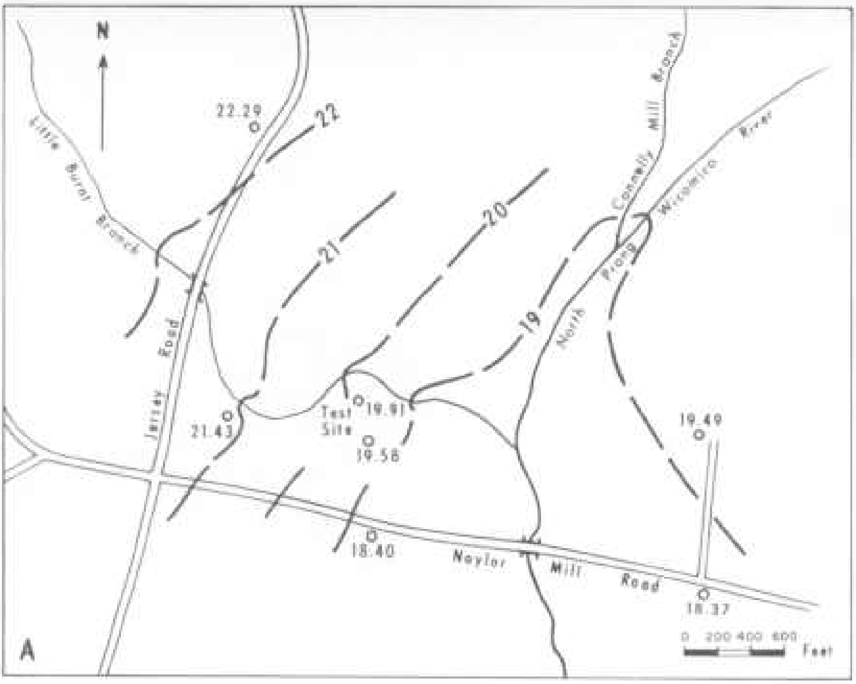
surface for zone B under nonpumping conditions. Positions of the contours in the figure indicate that the movement of ground water at the test site was southeastward toward Little Burnt Branch and North Prong Wicomico River. Ground-water levels at this time ranged from 22.3 to 18.4 feet above sea level in the area. For comparison, the shape of the potentiometric surface after 30 days of pumping is shown in Part B of figure 7.

Figure 8 is a profile along Little Burnt Branch showing the stream bottom, water levels in the stream, and potentiometric surfaces for zones A and B. The potentiometric surface for zone B, shown by a dashed line, was about 4 feet above the stream bottom. The potentiometric surface for zone A, shown by a dotted line, was about 1 foot above the bottom of the stream in most places. Water levels in the streams are generally less than 1 foot above the stream bottom except at Culver Pond and in the North Prong Wicomico River. During dry seasons, the stream channel in the first 1,000 feet downstream from the spillway of Culver Pond is often dry, and the movement in the section from 1,000 to 4,000 feet is sluggish. Water levels in zones A and B downstream from Jersey Road indicate upward movement of water toward the stream.

TABLE 2. Gains in streamflow in the reaches of North Prong Wicomico River upstream from Naylor Mill Road (all values in cubic feet per second.)

Date measured	Stream discharge				Total of columns 1, 2, & 3	Gain in flow in reach	Gain per mile of channel[2]
	1 Leonard Pond Run	2 Connelly Mill Branch[1]	3 Little Burnt Branch (Site 1)[1]	4 Naylor Mill Road (Site 5)			
8-06-63	3.45[3]	1.2	1.9	22.6	6.55	16.0	4.0
8-28-63	2.90[3]	1.0	1.6	18.5	5.5	13.0	3.2
9-25-63	2.98[3]	1.0	2.6	30.6	6.6	24.0	6.0
10-15-63	2.03[3]	.9[3]	1.32[3]	15.7	4.3	11.4	2.8
4-02-64	17.9[3]	5.9[3]	4.90[3]	58.0	28.7	29.3	7.3
8-28-64	1.54[3]	.5	1.5	17.2	3.5	13.7	3.4
12-01-64	1.85[3]	.6	1.4	17.0	3.8	13.2	3.3

[1]Except where noted, these values were estimated by assuming flow from Connelly Mill Branch to be 33 percent of the flow at Leonard Pond Run and the flow of Little Burnt Branch to be 8 percent of flow at Naylor Mill Road (Site 5).
[2]Based on 4 miles of channel, which includes reaches upstream from site 5 to U. S. Route 13 on North Prong Wicomico River, to Jersey Road (Site 1) on Little Burnt Branch and to Connelly Mill Road on Connelly Mill Branch.
[3]Measured.



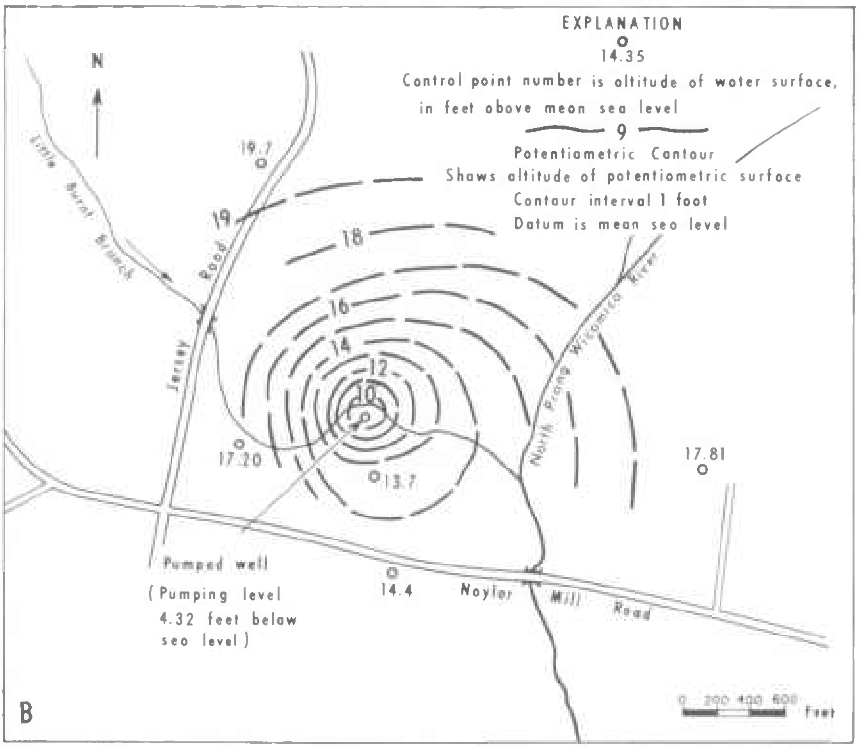


Figure 7. Map showing the potentiometric surface for zone B before the pumping test (A) and after 30 days of pumping (B).

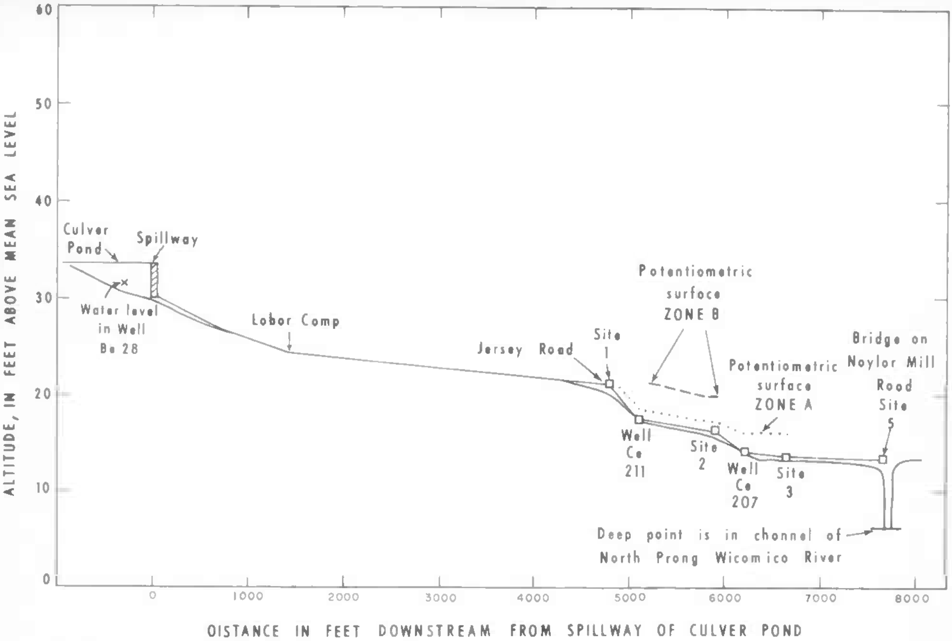


Figure 8. Profile along Little Burnt Branch showing the stream bottom and stage compared with ground-water levels.

PUMPING-TEST PROCEDURE

Well Wi-Ce 200[1] was pumped at 4,000 gpm for 30 days. The effects on ground-water levels were measured at 18 observation wells, and the effects on the flow of Little Burnt Branch were measured at three stations.

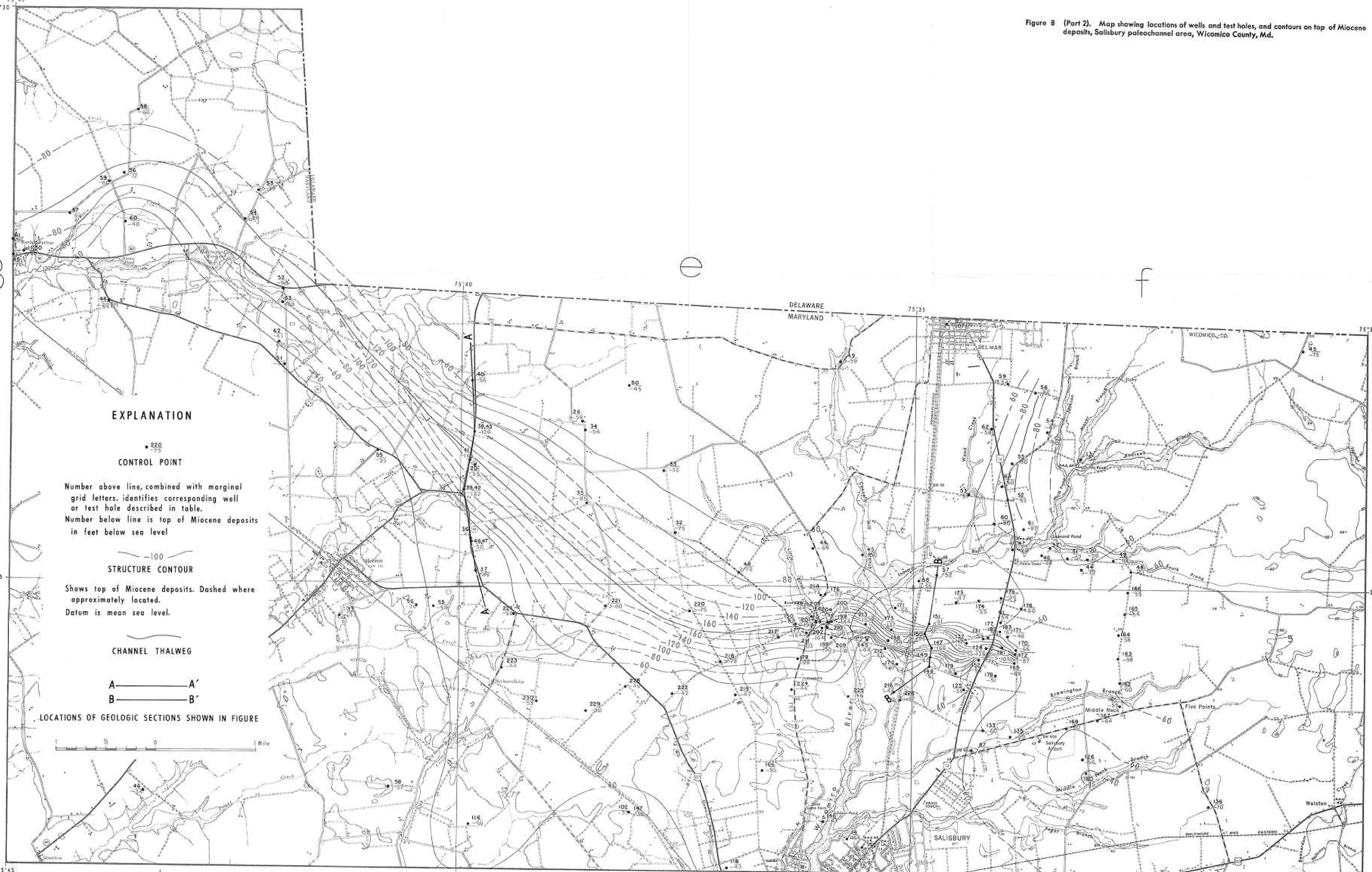
The following sections describe procedures used in making the test and measuring the effects of the pumping on ground-water levels and streamflow.

The following parameters were measured during the test:

1. Ground-water levels
   - (a) Zone A
   - (b) Zone B
   - (c) Manokin aquifer
2. Surface-water discharge data
   - (a) Little Burnt Branch
   - (b) North Prong Wicomico River
3. Quality-of-water data
   - (a) Chemical quality of water from (1) pumped well
     (2) Little Burnt Branch
     (3) North Prong Wicomico River
   - (b) Temperature of water from (1) pumped well
     (2) Little Burnt Branch

[1]See Appendix for construction details of well.

Figure 8 (Part 2). Map showing locations of wells and test holes, and contours on top of Miocene deposits, Salisbury paleochannel area, Wicomico County, Md.



4. Weather data
   (a) Precipitation (see Appendix)
   (b) Barometric pressure (see Appendix)

These parameters were measured during the following three phases:
1. Pre-pumping conditions
2. Pumping of the production well, Wi-Ce 200, at 4,000 gpm for 30 days.
3. Recovery of water levels for 30 days after cessation of pumping.

Sites of observation wells were selected to determine the effects of the pumping at varying distances and directions from the production well. Data for observation wells are presented in table 3, and locations are given in figures 1 and 2. Stream-gaging stations were located along Little Burnt Branch at sites as follows:

Site 1—1,100 feet upstream from the pumped well.
Site 2— 100 feet north of the pumped well.
Site 3— 600 feet downstream from the pumped well.

A constant pumping rate of 4,000 gpm was maintained for 30 days, except for the short shutdowns indicated on figure 13. Measurements of discharge were made with a 12-inch orifice in an 18-inch (OD)—17.25 (ID) pipe with a piezometer tube. One check of the pumping rate was made in the discharge ditch with a current meter, using standard stream-gaging methods. This check indicated that the discharge rate was 3,750 gpm, which is within the acceptable range of error.

Water from the pumped well was carried about 700 feet away from the pumped well before it was spilled to waste. It was piped the first 380 feet in a 24-inch corrugated pipe and the remaining 320 feet in a plastic-lined ditch. Upon leaving the ditch the water then spread laterally, some of it flowing into Little Burnt Branch and the rest flowing directly into the North Prong of the Wicomico River. Total leakage from the corrugated pipe was probably less than 25 gpm during the entire pumping test. Leakage from the plastic-lined ditch was negligible during the first few days of the test. However, the high velocity of water moving through the ditch gradually broke the plastic lining and by the end of the 30-day test had virtually destroyed its sealing effect. Some of the water probably leaked into the ground through the bottom of the ditch, but there was no noticeable decrease in flow due to the failure of the lining.

TABLE 3. Construction data for observation wells.

Well number	Distance from production well (feet)	Screen diameter (inches)	Screen position related to sea level (feet)	Aquifer or zone tested	Type of record C—continuous P—periodic measurement
	PART 1. Wells within the cone of depression				
Ce 195	49	1¼	9 to 10	A	P
196	89	2	9 to 10	A	P
197	149	1¼	8 to 9	A	P
200[1]	0	16	-55 to -135	B	P
204	50	3	-80 to -90	B	P
205	579	1¼	11 to 12	A	P
206	605	1¼	6 to 7	A	P
207	282	1¼	6 to 7	A	P
208	1,065	1¼	10 to 11	A	P
209	895	2	-90 to -98	B	P
210	305	2	-81 to -91	B	C
211	639	2	-87 to -97	B	C
212	2,190	2	-127 to -137	Manokin	C
213	1,900	2	-107 to -117	B	C
214	1,455	2	-61 to -71	B	C
215	830	1¼	[2]	B	P
	PART 2. Wells outside the cone of depression				
Be 28	5,800	4	-54 to -62	A	P
Cf 147	5,500	2	-19 to -39	A	P

[1]Production well.
[2]Exact length and position unknown.

SOURCES OF WATER AVAILABLE TO WELLS

The pumping-test site is located in an area rich in water that is available from several sources. The total amount of ground water available for future development at the test site will be from three sources: (1) water stored in the ground-water reservoir, (2) recharge water from local precipitation that replenishes the ground-water reservoir on a continuing basis, and (3) surface water from upstream sources in Little Burnt Branch and North Prong Wicomico River that will be induced into the aquifer when it is pumped at high rates.

A rough estimate indicates that sediments forming the channel-fill deposits contain in storage about 7 billion gallons of water, of which half may be available to wells. The estimate assumes that the channel-fill deposits are about half a mile wide, 2 miles long, have a saturated thickness of at least 120 feet, and a porosity of 30 percent.

Sources of water available to the pumping well during the pumping test can be classified as follows:

1. Local precipitation
2. Water in storage
   - (a) Stored in zone B
   - (b) Stored in formations adjacent to zone B
   - (c) Stored in Little Burnt Branch (pools and ponds at weirs)
   - (d) Stored in the North Prong Wicomico River
3. Transient water
   - (a) Ground water from upgradient which discharges under nonpumping conditions to: (1) Little Burnt Branch
     (2) North Prong Wicomico River
   - (b) Surface water flowing into the area from upper reaches of: (1) Little Burnt Branch
     (2) North Prong Wicomico River

Figure 9 is a chart showing that under condition 1, only a few of the above sources are called upon to satisfy relatively small pumping rates; that under condition 2, some additional sources will be called upon to satisfy pumping rates of an intermediate type; and under condition 3, all sources will be called upon to supply the highest pumping rates.

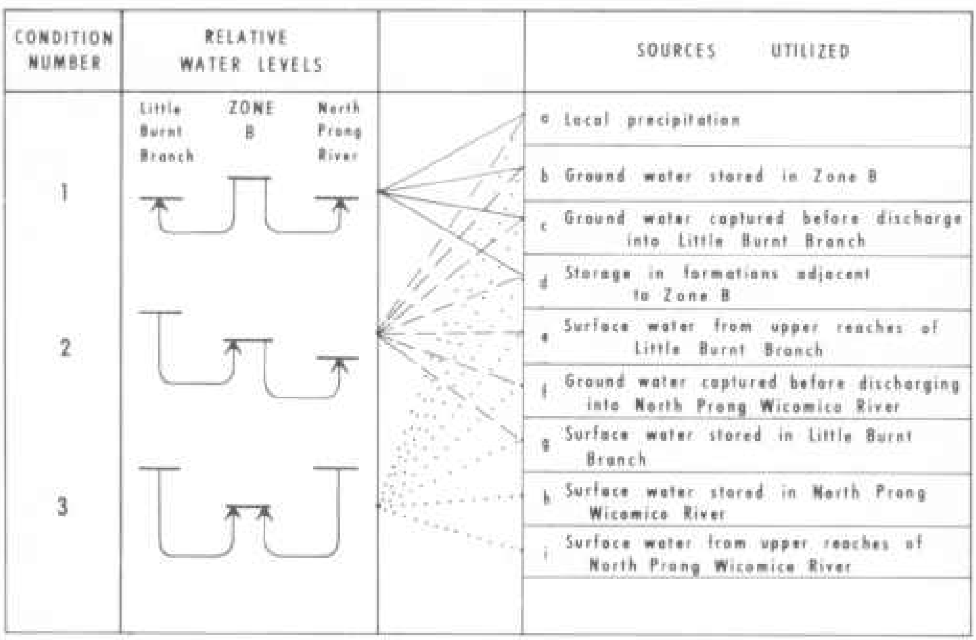


Figure 9. Chart showing sources of water available to the pumping well.

Condition 1 would exist at pumping rates up to a few hundred gallons per minute, and as long as the head on zone B remains higher than the levels of both Little Burnt Branch and the North Prong Wicomico River. Under this condition, water pumped from the ground would be from storage at first but later would be ground water intercepted in transit before being discharged into the streams. Precipitation in the local area would supplement these sources.

Condition 2 would exist whenever pumping rates (possibly 400-4,000 gpm) are great enough to draw the head on zone B below the level of Little Burnt Branch but not great enough to lower it below the level of North Prong Wicomico River. Sources of water supplying this condition include those supplying condition 1 plus three other sources. With the head in zone B lower than the water levels of Little Burnt Branch, surface water in Little Burnt Branch moves through the streambed toward the aquifer. Because the flow of Little Burnt Branch is usually less than 2,000 gpm and the streambed is quite permeable, extended periods of pumping at rates greater than 4,000 gpm would divert the entire flow of the stream to the aquifer. Thus, both the water stored and the water flowing in Little Burnt Branch must be considered exhaustible sources. When these sources are no longer available, the cone of depression will develop other sources, undoubtedly by capturing larger proportions of water naturally discharging to North Prong Wicomico River.

Condition 3 will exist when the head on water in zone B is drawn below the levels of both Little Burnt Branch and North Prong Wicomico River. Sources of water when this condition exists, include that from North Prong Wicomico River as well as those sources supplying conditions 1 and 2. Development of this condition requires a reversal of gradient to cause movement of water from North Prong to the aquifer.

EFFECT ON HYDROLOGIC SYSTEM

The impact of the pumping on the existing hydrologic system was substantial and prolonged, affecting ground-water levels and the flow of nearby streams, thus providing data regarding the functioning of the system and the interrelationship between the aquifer and the surface streams.

Changes in Ground-Water Levels

Before the drawdown phase of the test commenced, ground-water levels in zone B were about 20 feet above sea level (see fig. 7A). Pumping of well Wi-Ce 200 at 4,000 gpm for 30 days lowered its water level to 4 feet below sea level for a total drawdown of 24 feet and caused the cone of depression to develop in the piezometric surface (fig. 7B).

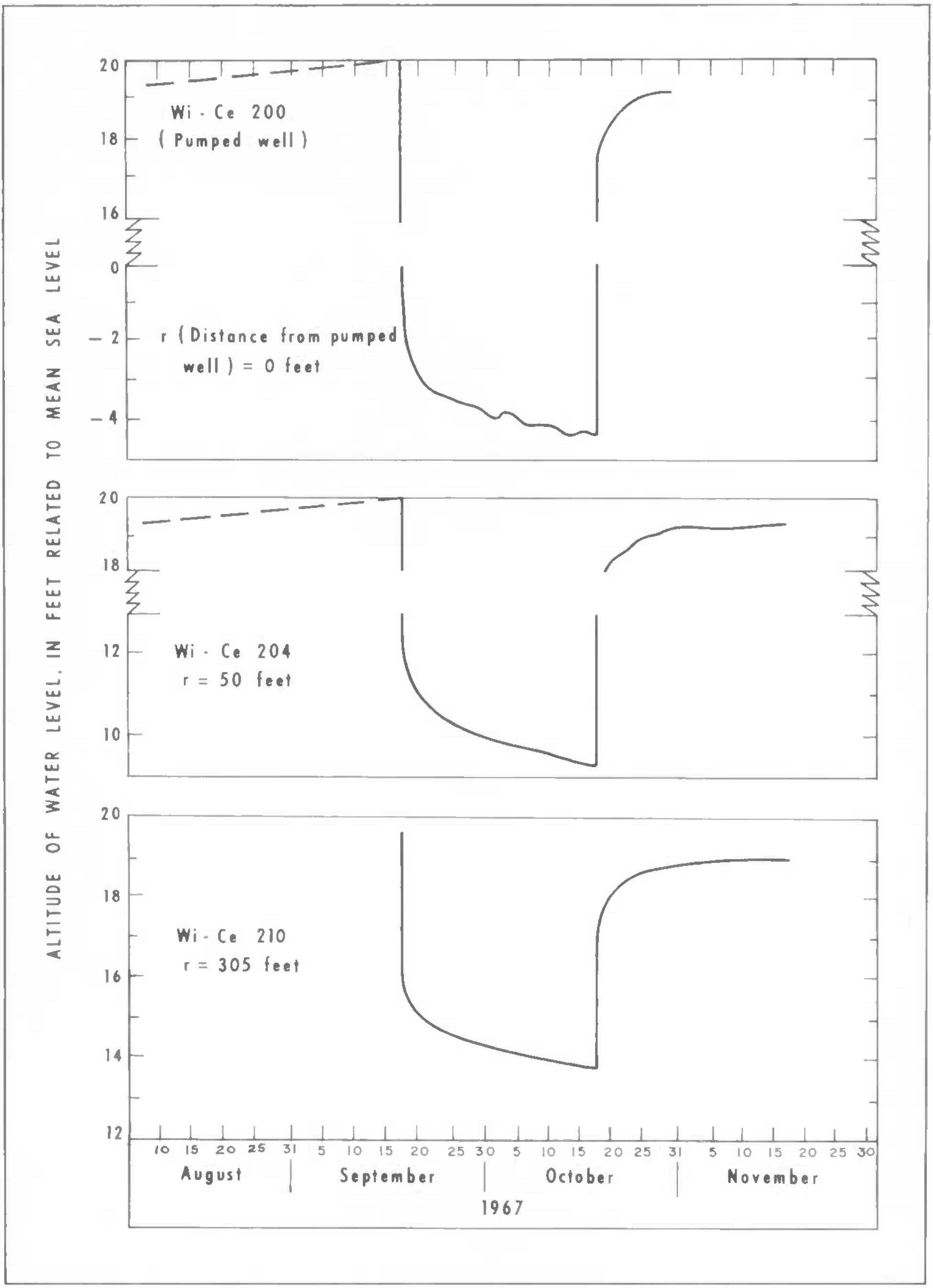


Figure 10. Hydrographs showing fluctuations of water levels in zone B in wells WI-Ce 200, 204, and 210 during the period of study.

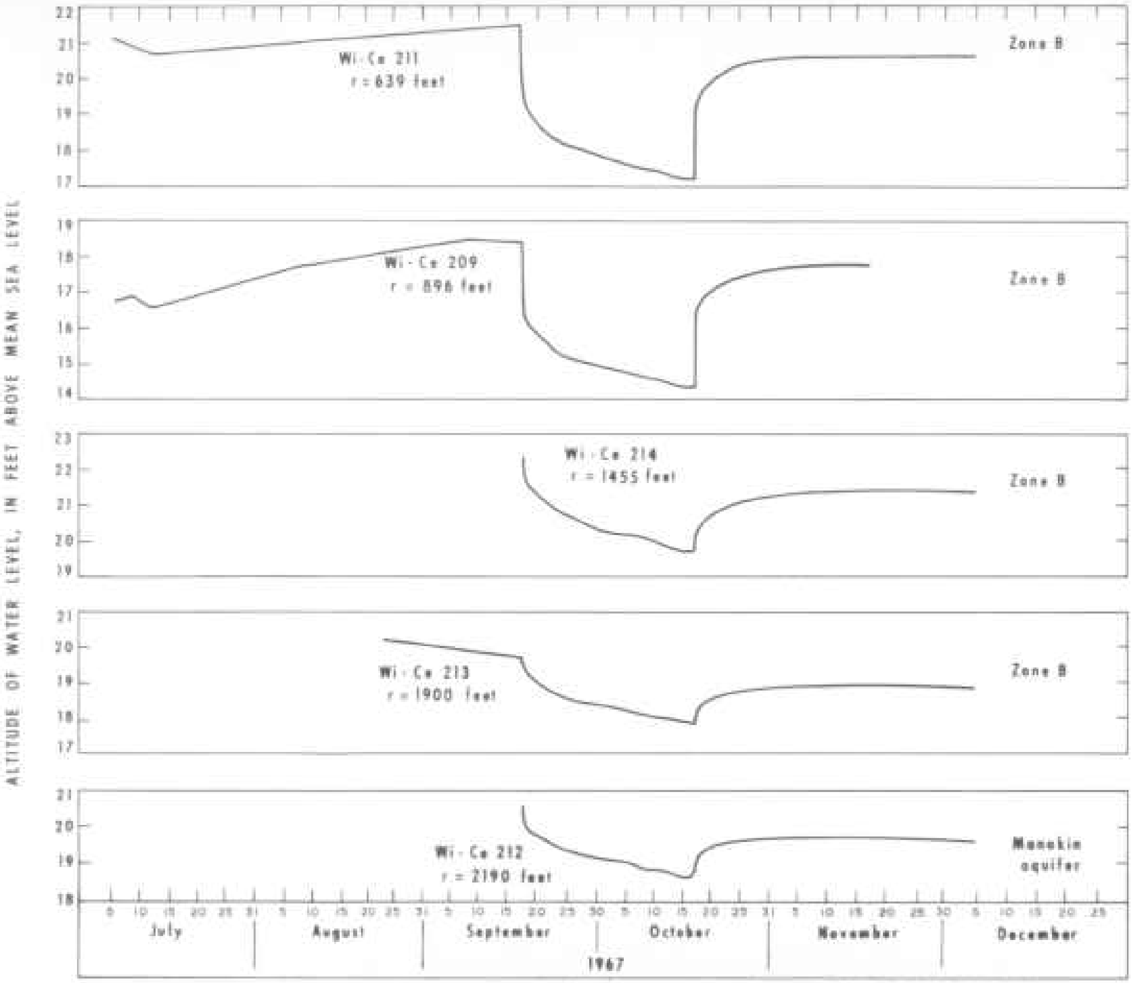
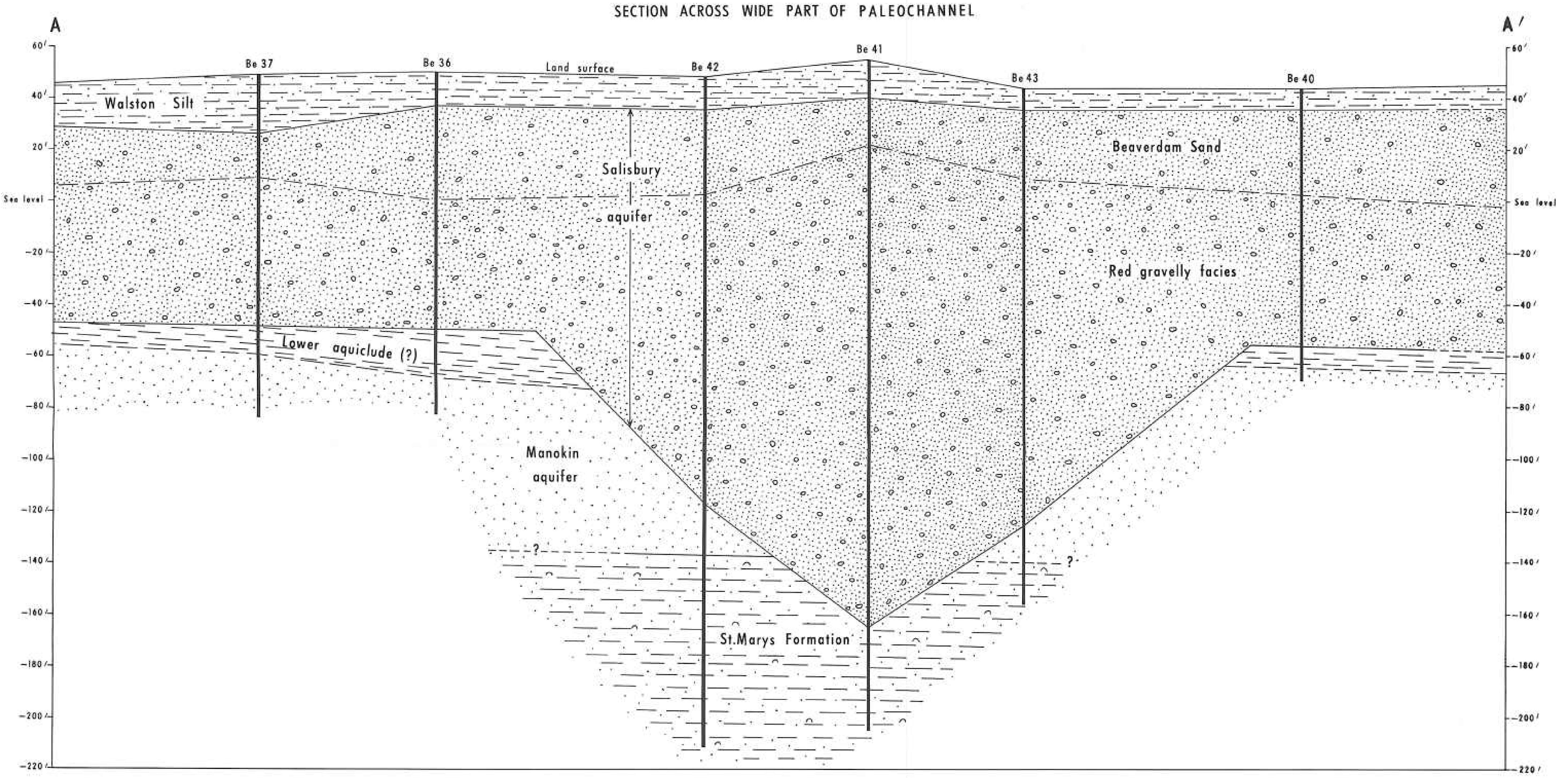
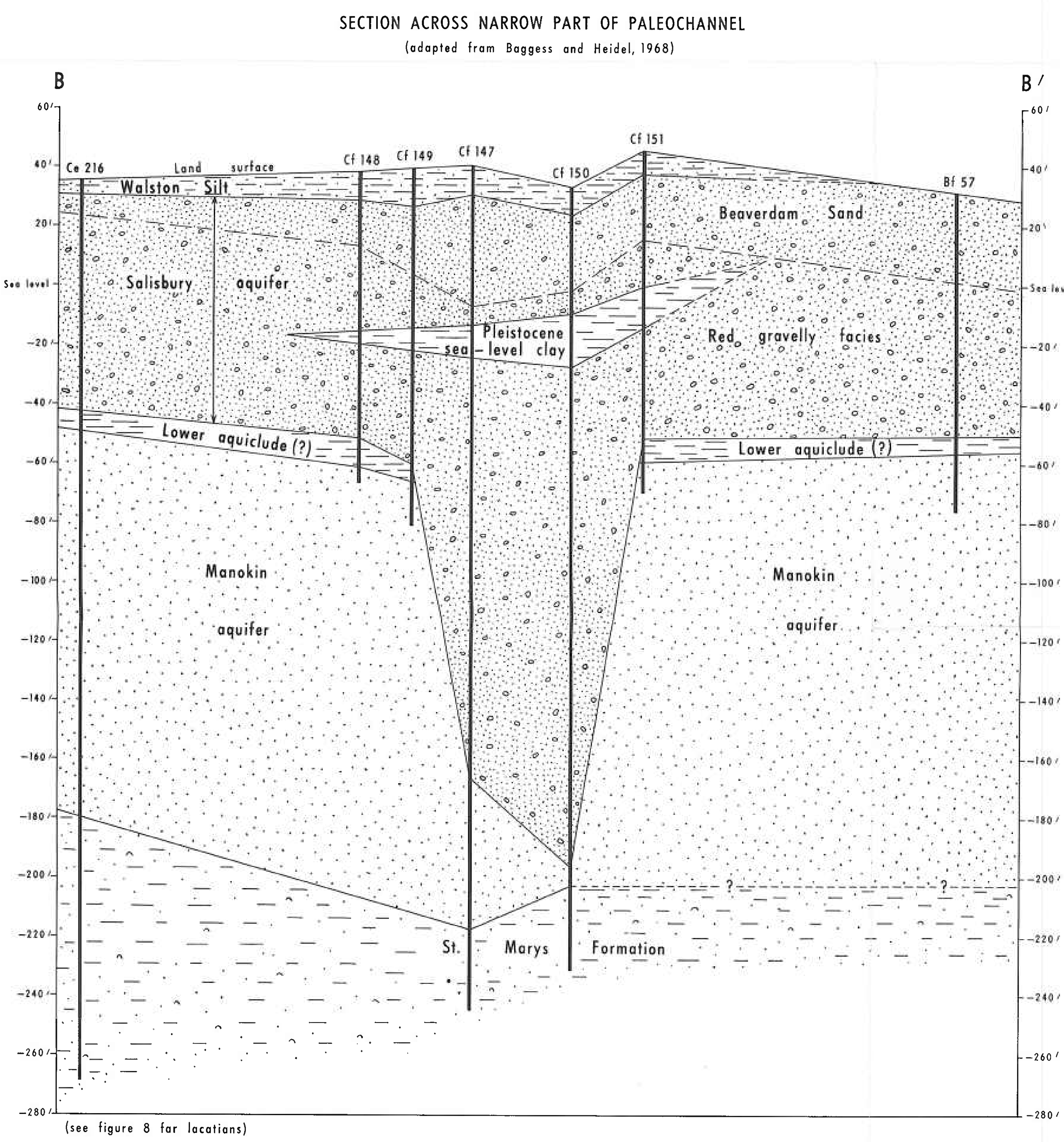


Figure 11. Hydrographs showing water-level fluctuations in zone B in wells Wi-Ce 209, 211, 213, and 214 and in the Manokin aquifer in well Wi-Ce 212 during the period of study.





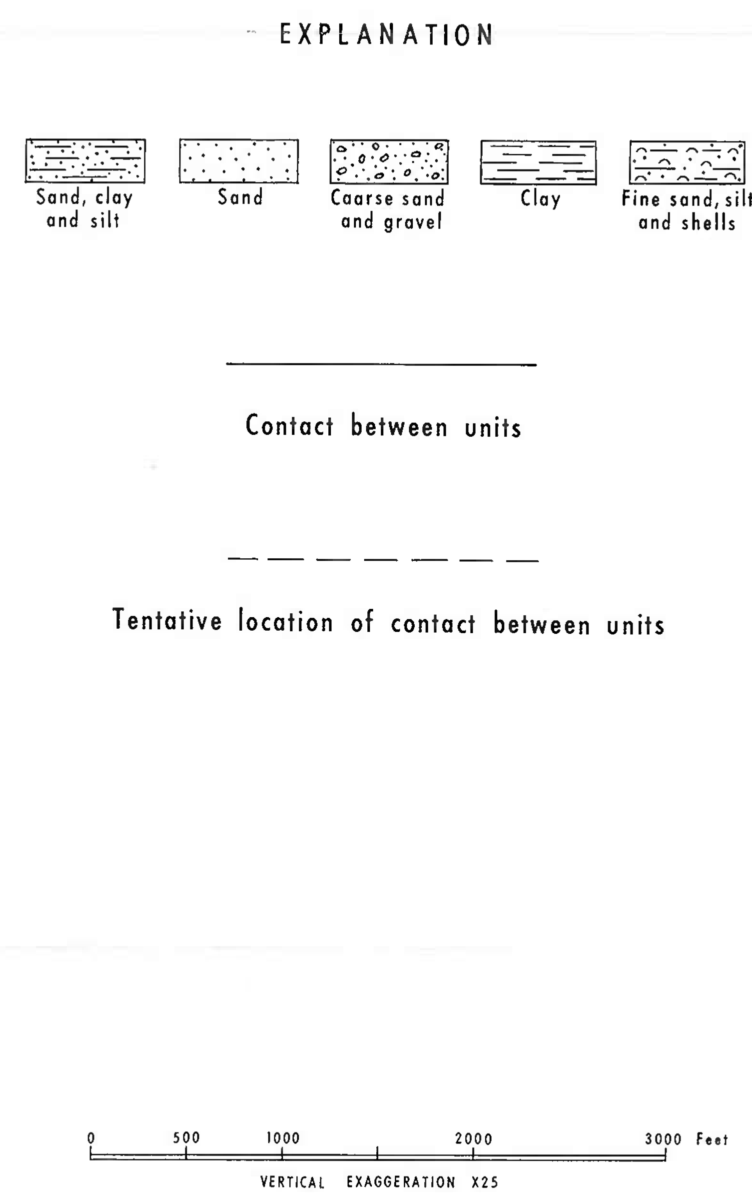


Figure 11 (Part 2). Generalized geologic sections across Salisbury paleochannel, Wicomico County, Md.

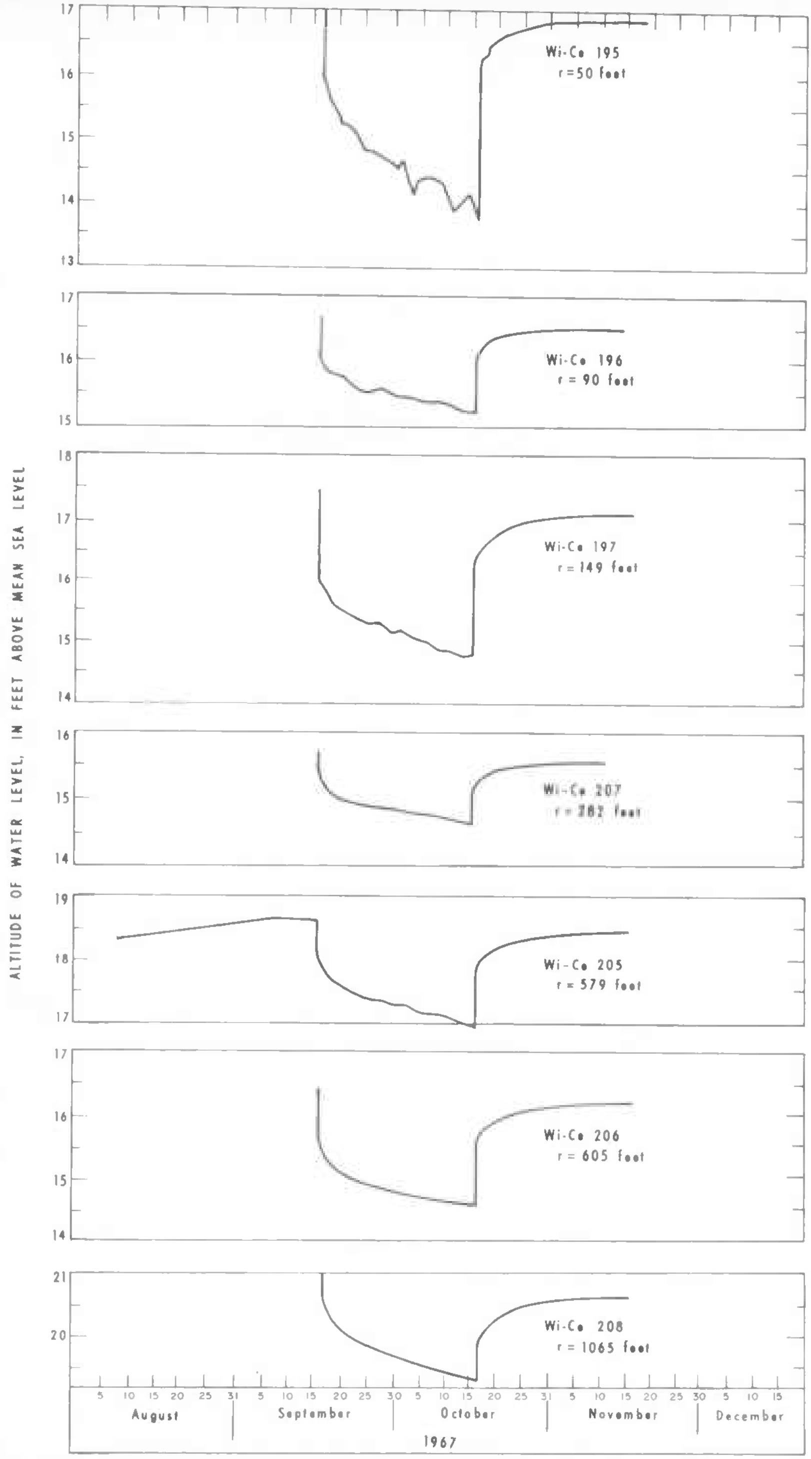
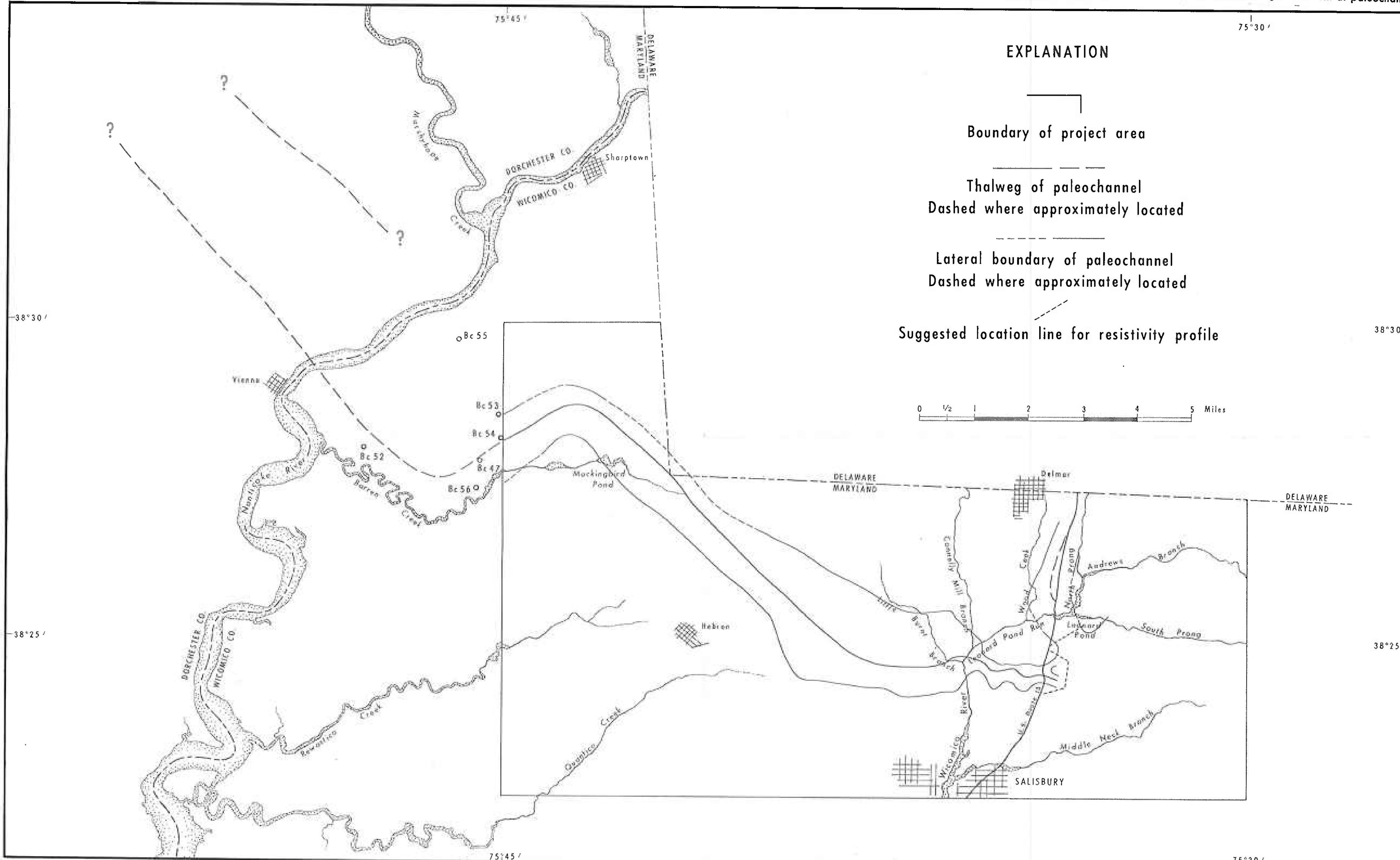


Figure 12. Hydrographs showing fluctuations of water levels in wells tapping zone A during the period of study.

Figure 12 (Part 2). Map showing hypothesized regional extent of paleochannel.



This pumping changed the direction of ground-water flow in the immediate vicinity of the pumping well. Where the ground water was moving to the stream before the test, the gradient was reversed, and water that would have moved from the ground to the stream was captured by the pumping well.

Water levels in all observation wells constructed for this test, in zones A and B and the Manokin aquifer, were affected by the pumping (figs. 10-12).

These hydrographs are presented by zones in order of increasing distance from the production well. Water levels in two outlying wells, Wi-Be 28 and Wi-Cf 147, were measured during the test but were not affected by the pumping.

A complete record of water-level fluctuations in zone B from July 13 to November 18, 1967, as measured in observation well Wi-Ce 210 (305 feet from the pumping well), is given in figure 13. Notations of daily precipitation and causes of water-level changes have been made on the record.

Table 4, which summarizes the water-level data, shows how the pumping of well Wi-Ce 200 affected the observation wells and how the water levels recovered after the pumping ceased. The last column of the table provides a comparison of water levels at the end of 30 days of recovery with static levels before the test commenced. In all cases, the water levels after 30 days of recovery were slightly lower than the initial static, most likely because of the natural recession of water levels from the unusually wet conditions at the beginning of the test.

Figure 14 shows the configuration of a part of the cone of depression for zone B, as determined with seven control points on October 18, 1967, after 30 days of pumping. The general shape of the cone of depression, where defined, was shallow, gently sloping, and rounded. The actual shape of the complete cone was probably elongated in the east-west direction because of the limited lateral extent of zone B shown in figure 5. The shallowness and gentle sloping character of the cone (the greatest drawdown was 24.23 feet at the pumping well) reflects the relatively high transmissivity of the aquifer.

Water levels in zone A, the shallow aquifer, were measured in wells 7 feet deep at five stations along Little Burnt Branch. Before the test, water levels in these wells stood as much as 1 foot above stream level. When pumping started, water levels declined to points below stream level in all wells except Wi-Ce 206. Following is a list of the shallow wells tapping zone A showing altitudes of: (1) static water levels, (2) water levels at the end of the 30-day pumping test, and (3) levels of the water surface of the stream at the well sites.

Well number Wi-Ce	Altitude of stream surface near the well sites (feet above mean sea level)		Net change (feet)	Altitude of water level in wells (feet above mean sea level)		Net change (feet)
	Before test	After 3o days		Before test	After 30 days	
195	16.27	16.07	-0.20	16.96	13.76	-3.20
196	16.27	16.07	- .20	16.62	15.20	-1.42
197	16.27	16.07	- .20	17.42	14.78	-2.64
205	17.50	17.23	- .27	18.60	16.99	-1.61
206	14.26	14.18	- .08	16.43	14.57	-1.88
207	15.09	14.80	- .29	15.73	14.68	-1.05
208	.....	.....	.....	21.00	19.29	-1.71

Figure 15 shows how water levels declined during the period of pumping in:

1. Wells Wi-Ce 195, 196, and 197 in zone A.
2. Well Wi-Ce 204 screened in zone B (50 feet from the pumped well).
3. Well Wi-Ce 200, the pumped well; and
4. Little Burnt Branch at site 2.

Comparison of data for wells Wi-Ce 204 and Wi-Ce 195, both of which are about 50 feet from the pumped well, shows that drawdown in zone B was at least four times the drawdown in zone A. Thus, as was expected, the maximum drawdown was in the principal aquifer, zone B. The overlying shallow aquifer, zone A, acted as the conduit for transmission of diverted streamflow and had proportionately less drawdown.

Comparison of water levels in wells Wi-Ce 206 and water levels in Little Burnt Branch at site 3 (about 10 feet to the north of the well) shows that, although water levels declined 1.88 feet in zone A in response to pumping, the potentiometric surface of the aquifer was still 0.39 foot above the stream level. These data indicate that at this place within the cone of depression, the direction of movement of water continued to be from the ground to the stream, but there was a reduction in the quantity so moving.

Observations of water-level fluctuations were made in one well, Wi-Ce 212A, tapping the Manokin aquifer at a distance of 2,190 feet from the pumping well. Static water levels in this aquifer were about 1.2 feet higher than water levels in Wi-Ce 212B, which was screened in zone A at a depth of 20 feet. Figure 11 shows that water levels in the Manokin aquifer responded to pumping in a manner similar to that of water levels in zone B of the Pleistocene deposits.

Table 4. Drawdown and recovery data for observation wells. (all water levels are in feet below measuring point)

Well Number	Distance from pumping well (feet)	Static water level 9-18-67	Drawdown phase: 1 hour WL (water level)	1 hour Dd (drawdown)	24 hours WL	24 hours Dd	7 days WL	7 days Dd	30 days WL	30 days Dd	Recovery phase: 1 hour WL	1 hour Rec. (recovery)	24 hours WL	24 hours Rec.	7 days WL	7 days Rec.	30 days WL	30 days Rec.	Difference between water level on 11-18-67 and 9-18-67
WI Ce 201 b/	49	3.19	4.13	0.94	4.22	1.03	5.25	2.06	5.15	2.05	5.15	1.34	4.00	2.47	3.10	5.01	3.28	7.12	+0.10
WI Ce 202 b/	49	.13	.46	.15	.85	.72	1.16	1.25	1.30	1.43	.05	.24	.18	1.05	.30	.02	.03	1.00	+ .18
WI Ce 203 b/	110	3.16	5.26	2.13	4.96	1.80	4.85	2.00	3.10	2.34	4.73	1.35	3.08	1.71	3.09	2.16	3.08	2.32	+ .50
[illegible] a/	0	12.46	-	-	35.40	23.30	35.41	23.52	34.25	34.23	17.95	22.22	13.06	28.30	10.90	27.22	-	-	-
WI Ce 204	90	11.02	18.22	7.05	20.35	7.13	21.17	9.23	25.22	10.03	16.03	6.34	11.63	5.70	11.13	8.00	12.11	10.10	+ .59
WI Ce 205 b/	174	3.73	4.31	.55	4.31	.75	4.34	1.11	3.40	1.43	3.73	.35	4.43	.95	4.11	1.27	3.95	1.43	+ .14
WI Ce 206 b/	800	1.37	2.10	.73	2.42	1.30	3.40	1.71	3.25	1.85	3.59	.48	2.09	1.00	1.53	1.44	1.83	1.56	- .22
WI Ce 207 b/	232	7.38	2.24	.45	3.32	.15	3.40	.23	3.27	1.30	2.11	.30	7.23	.02	7.00	.03	7.00	.31	+ .14
WI Ce 208 b/	1000	1.23	1.47	.18	1.78	.54	3.24	1.11	1.36	1.71	-	-	1.77	.75	1.00	1.14	1.00	1.23	- .09
WI Ce 209	530	33.50	35.17	1.27	16.34	3.94	17.13	3.64	17.25	4.25	-	-	22.31	1.22	14.11	3.10	15.16	2.33	- .06
WI Ce 210	360	21.12	24.02	2.70	25.50	4.04	26.49	4.29	27.50	5.34	24.31	3.03	23.41	5.30	25.45	4.22	22.00	5.30	+ .10
WI Ce 211	325	3.30	3.41	1.73	5.16	1.43	7.08	3.30	7.71	4.53	4.20	1.21	1.33	7.33	4.08	3.33	4.33	7.08	+ .49
WI Ce 212	1550	17.515	17.855	.34	18.47	.48	18.89	1.37	18.71	1.59	16.73	.18	18.10	.01	18.77	.04	15.70	1.71	+ .58
WI Ce 213	1800	21.35	20.44	.23	20.90	.15	21.32	1.38	22.29	1.07	21.30	.12	21.33	.17	21.10	.01	21.07	1.05	+ .49
WI Ce 214	1455	21.90	21.45	.29	23.35	.75	25.20	1.50	24.19	2.19	22.90	.23	23.43	.75	22.30	1.89	22.43	1.70	+ .09

a/ Pumped well.

b/ Indicates 7 foot well.

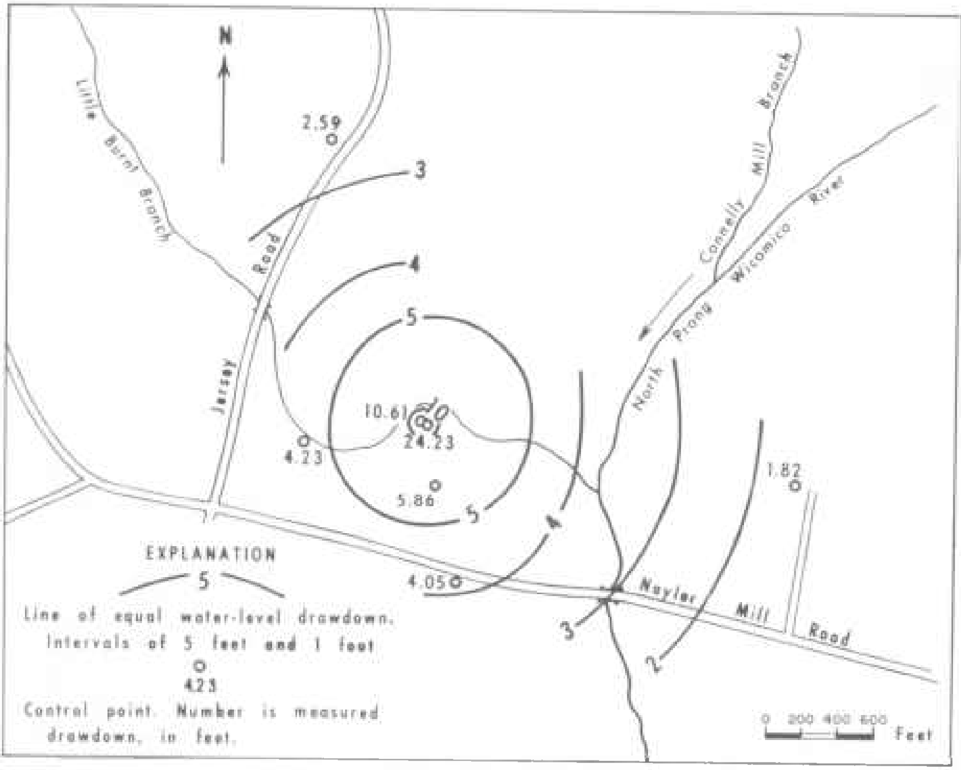


Figure 14. Map showing the drawdown of the potentiometric surface for zone B caused by the 30-day pumping test.

Changes in Streamflow

Streamflows in Little Burnt Branch and North Prong Wicomico River were affected by pumping during the test, showing that there is a hydraulic connection between the streams and the aquifer. Pumping affected the flow of Little Burnt Branch in two ways: (1) by decreasing the rate at which the aquifer discharged water into the stream; and (2) by diverting water already in the stream through the streambed into the aquifer. North Prong Wicomico River was affected by a decrease in the rate at which the aquifer discharged water into the stream, but no determination has been made as to whether or not water already in the stream was diverted into the aquifer.

Figure 16 is a hydrograph showing streamflow at the three stations on Little Burnt Branch. The graph shows that streamflow increased in the downstream direction before pumping began but decreased in this direction with continued pumping. Streamflow promptly returned to the original relationship of increasing flow downstream with termination of the pumping phase.

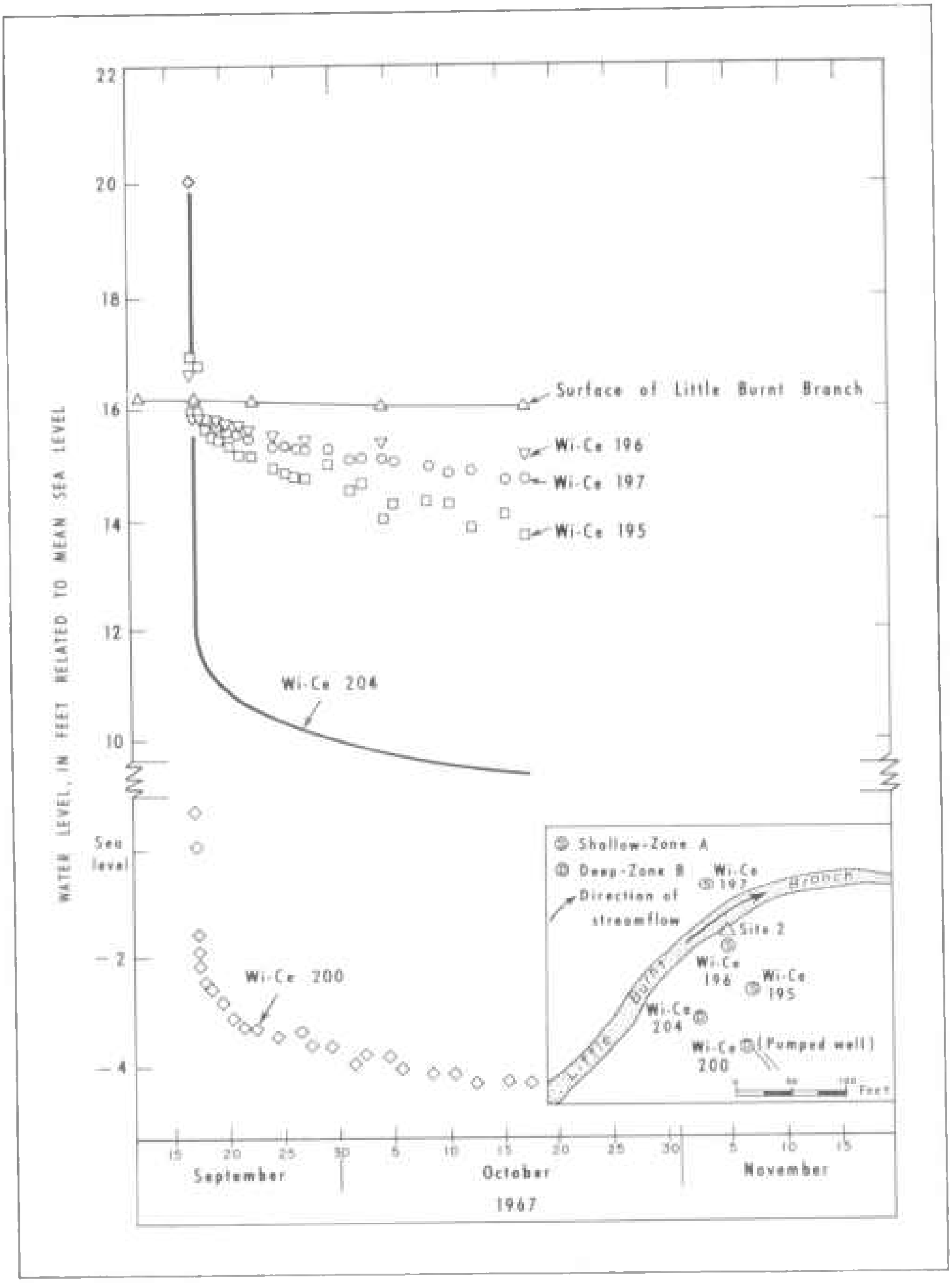


Figure 15. Hydrographs showing relationships of the stages of Little Burnt Branch to the ground-water levels in zone A and B.

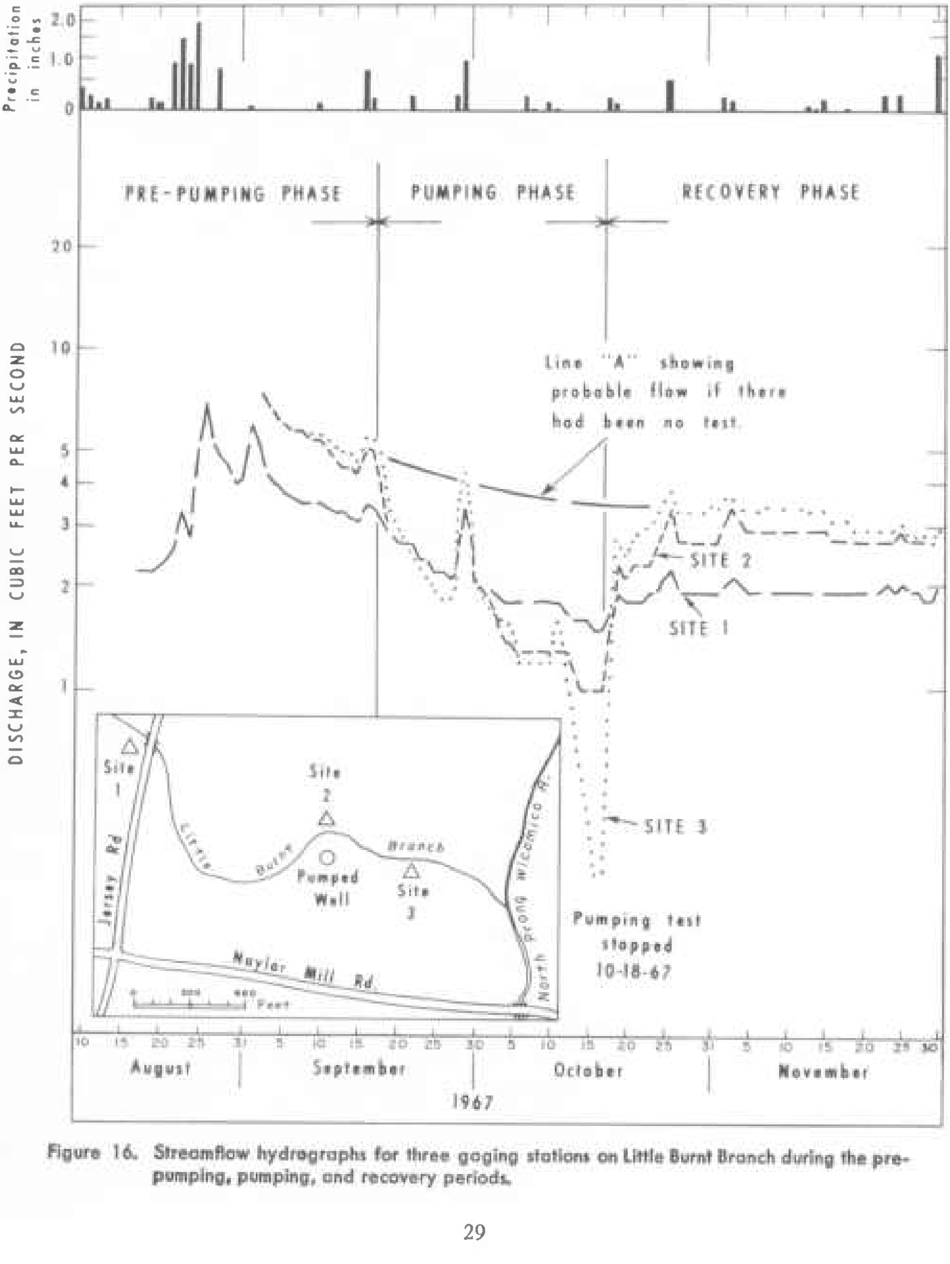


Figure 16. Streamflow hydrographs for three gaging stations on Little Burnt Branch during the pre-pumping, pumping, and recovery periods.

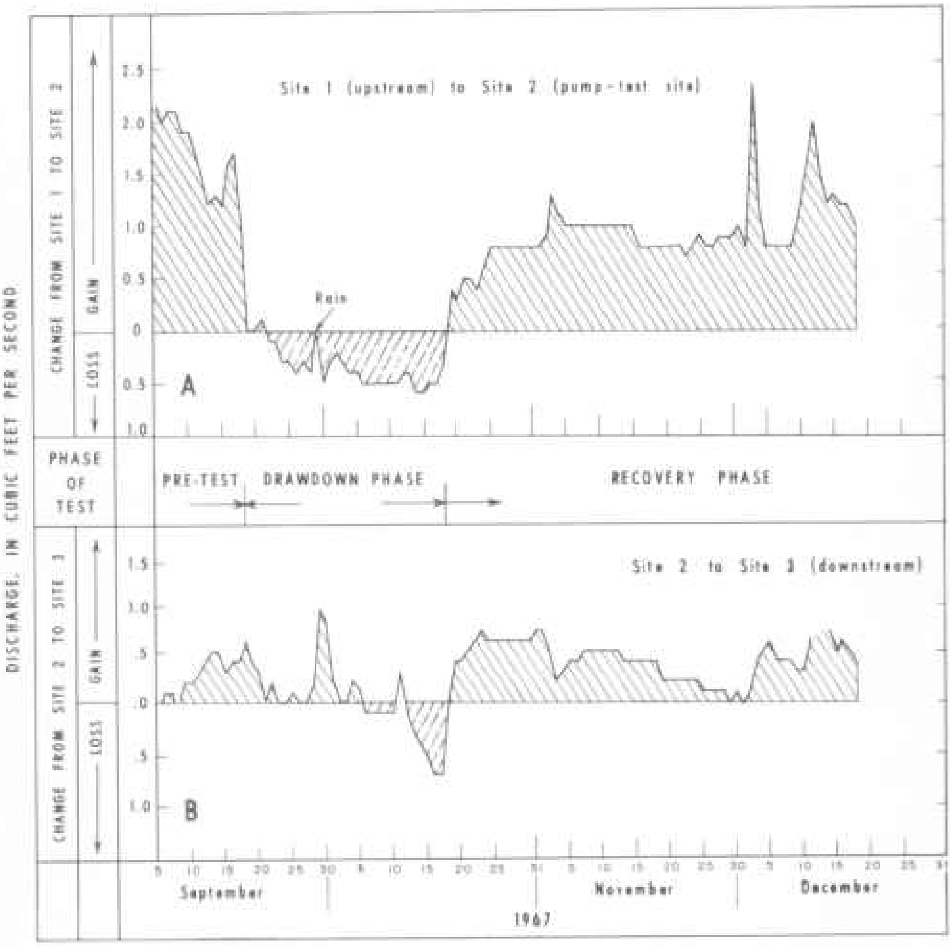


Figure 17. Graph showing streamflow gains for Little Burnt Branch during non-pumping periods and streamflow losses during the 30-day pumping period.

Graph A of Figure 17 shows the gain or loss in streamflow between site 1 and site 2 during the periods before, during, and after the drawdown phase of the test. Graph B of the same figure shows the gain or loss in flow between sites 2 and 3 for the same period. These graphs show that, under nonpumping conditions and negligible precipitation, the flow at site 2 is about 0.9 cfs (400 gpm) greater than flow at site 1 and that flow at site 3 is about 0.4 cfs (180 gpm) greater than flow at site 2. These graphs also show that in early September the flow of Little Burnt Branch was still receding from the high flow of late August, when there was heavy precipitation in the Salisbury area. This high flow probably obscured the total effect of the pumping test on Little Burnt Branch.

On September 17, one day before the pumping test began, the flow at site 2 was 1.7 cfs (765 gpm) greater than the flow at site 1, and the flow at site 3 was 0.4 cfs (180 gpm) greater than at site 2. By September 27, the flow was 2.1 cfs (945 gpm), 1.8 cfs (810 gpm), and 1.8 cfs (810 gpm) at sites 1, 2, and 3, respectively. Later in the pumping test, the flows at the downstream sites decreased enough to show losses of as much as 0.6 cfs (270 gpm) between site 1 and site 2 and 0.7 cfs (315 gpm) between site 2 and site 3. Losses appear to increase with time and probably would have been substantially greater if pumping had been continued. The sharply declining trend shown on the hydrograph for site 3 from October 15 to 18 (figure 16) suggests that flow at this site would have ceased if the test had continued for 3 or 4 more days.

The pumping test affected North Prong Wicomico River by reducing by several cubic feet per second, the quantity of water naturally discharging from the aquifer to the stream. Attemps to discern the effect of the pumping test on North Prong Wicomico River by analyzing simultaneous measurements of streamflow at sites 4 and 5 (see fig. 2) have been inconclusive, probably because the possible ranges in errors of the measurements were greater than the effect in this short reach.

The decline in head in zone B at North Prong Wicomico River (about 800 feet upstream from site 5), as determined by interpolating between drawdown measurements near the production well and drawdown measurements at well Wi-Ce 213, (900 feet east of the river) was 0.9 foot after 1 hour of pumping, 1.5 feet after 8 hours, and 3 feet after 30 days. These declines probably brought the head on water in zone B to a level close to or slightly below the water surface of North Prong Wicomico River and thus decreased or stopped the movement of ground water into the stream in the vicinity of the production well.

Interchanges Between Ground Water and Surface Water

Knowledge of the ground water—surface water relation will be essential in estimating long-term yields of the aquifer because induced streamflow will probably be the major source of recharge to the aquifer if it is eventually developed to its capacity. Studies of these relations in other areas have been made by Reed, Deutsch, and Wiitala, 1966; Walton, Hills, and Grundeen, 1967; Weeks, Ericson, and Holt, 1965; Moore and Jenkins, 1966; Norris and Fidler, 1969; Rorabaugh, 1956; and Weeks, 1969. Data collected during this test show that pumping at high rates for extended periods of time would probably capture all water that normally flows in Little Burnt Branch, a relatively small stream. The cone of depression for the aquifer definitely extended beyond the nearby reach of North Prong Wicomico River during the test and reduced the quantity of ground water discharged into the river, although the aquifer may not have received water from the river.

The mean annual flow of North Prong Wicomico River is about 35 mgd, and there appear to be no downstream users of water from it. The rate at which water can move from the stream to the aquifer depends on the vertical permeability of materials in the streambed and the aquifers, the hydrostatic head differentials, and the area covered by surface water. It seems reasonable to believe that large quantities of water can be induced into the aquifer by means of pumping wells, if the hydraulic connection between the stream and aquifer is adequate. Evidence that the connection is less than perfect is in the difference in water levels found in zones A and B. (See figure 15.) Evidence that a good hydraulic connection exists is shown by the effect that pumping from the aquifer had on Little Burnt Branch during the test. During the later part of the test, about 0.8 mgd of water was lost in the reach between sites 1 and 3, which has an area of about 27,000 square feet. Thus, the average rate of infiltration through the streambed under the hydraulic gradients that existed at the time, was about 30 gpd per square foot.

Damming of the North Prong Wicomico River at Naylor Mill Road would increase the area covered by surface water and would increase the head differential. However, it might increase the rate of siltation, and that in turn would probably decrease the infiltration capacity of the streambed.

HYDRAULIC CHARACTERISTICS OF THE AQUIFER

The valley-fill aquifer may be described as an aquifer of small areal extent, bounded on two sides by valley walls, with transmissivity and permeability changing rapidly in both horizontal and vertical directions, bordered by a small nearby source of recharge (Little Burnt Branch) and a more distant large source of recharge (North Prong Wicomico River), with a leaky confining bed above (zone A) separating it from the two streams, and with a leaky confining bed below separating much of it from the Manokin aquifer—an extensive aquifer of much lower transmissivity than zone B. During the 30-day test, the various recharging sources (Little Burnt Branch, North Prong Wicomico River, and leakage from zones A and C) and the negative boundaries (valley walls of the channel deposits) became effective at different times and with different degrees of effectiveness. The net effect of the positive boundaries was to decrease the rate of change of drawdown with time, and the effect of the negative boundaries was to increase the rate of change of drawdown with time.

Figures 18 and 19 show plots of drawdown or recovery versus time for the pumping well and the six observation wells screened in the most permeable part of the aquifer (zone B). The Theis type curve is superimposed on each of the plots. The plots for the pumping well and the four nearest observation wells show a deviation from the Theis type curve caused by recharging boundaries. However, the two distant observation wells (Ce 213 and 214), on the opposite side of the streams from the pumping well, show deviations from the Theis type curve caused by negative boundaries (probably the valley walls of the channel deposits).

The transmissivity of the principal aquifer (zone B) has been calculated by obtaining match-point coordinates from the early part of the time-versus-drawdown (or recovery) curves for the pumping well and observation wells Ce 204, 209, 210, and 211. The calculated values for coefficients of transmissivity are as follows:

Observation well number	Distance from pumping well	Drawdown or recovery data	Part of curve used for calculation	Coefficient of transmissivity (gpd per foot)	Estimate of accuracy of tranmissivity value
Wi-Ce 200	0	Rec	1st 30 min	350,000	Fair to Good
Wi-Ce 204	50 feet	Dd	1st 30 min	430,000	Good
Wi-Ce 209	896 feet	Dd	1st 40 min	360,000	Good
Wi-Ce 210	305 feet	Rec	1st 30 min	600,000	Fair to Poor
Wi-Ce 211	639 feet	Rec	1st 20 min	60,000	Fair to Poor

The best value for coefficient of transmissivity for the principal aquifer (zone B) is on the order of 400,000 gpd per foot (the average for the first three values listed above.) Inasmuch as the pumping well and nearby observation wells are constructed in the thickest section of sand and gravel, the transmissivity of 400,000 gpd per foot is probably a maximum value for the aquifer.

The coefficient of permeability is about 5,000 gpd per foot, based on the transmissivity of 400,000 gpd per foot and an average thickness of 80 feet. This value of permeability is comparable to that of coarse sand and gravel deposits found elsewhere in the Coastal Plain.

The coefficient of storage (S) could not be determined by analysis of the pumping-test data. The value for S obtained by analyzing the early part of the time versus drawdown curves was about 0.002. However, this value is for artesian conditions that were effective in the aquifer during the early minutes of pumping before gravity drainage from zone A. During long-term pumping it would be much higher (probably

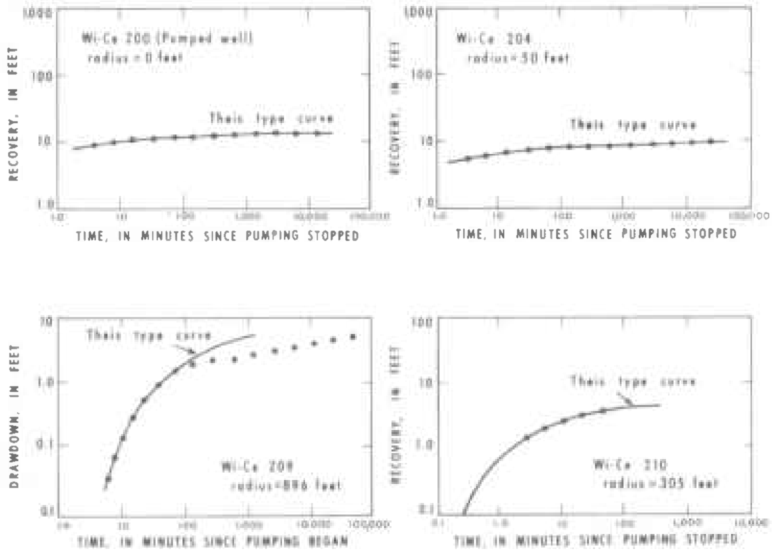


Figure 18. Log-log plots of drawdown or recovery versus time for wells Wi-Ce 200, 204, 209 and 210.

0.10 to 0.20) and would approach the value for the specific yield of the aquifer.

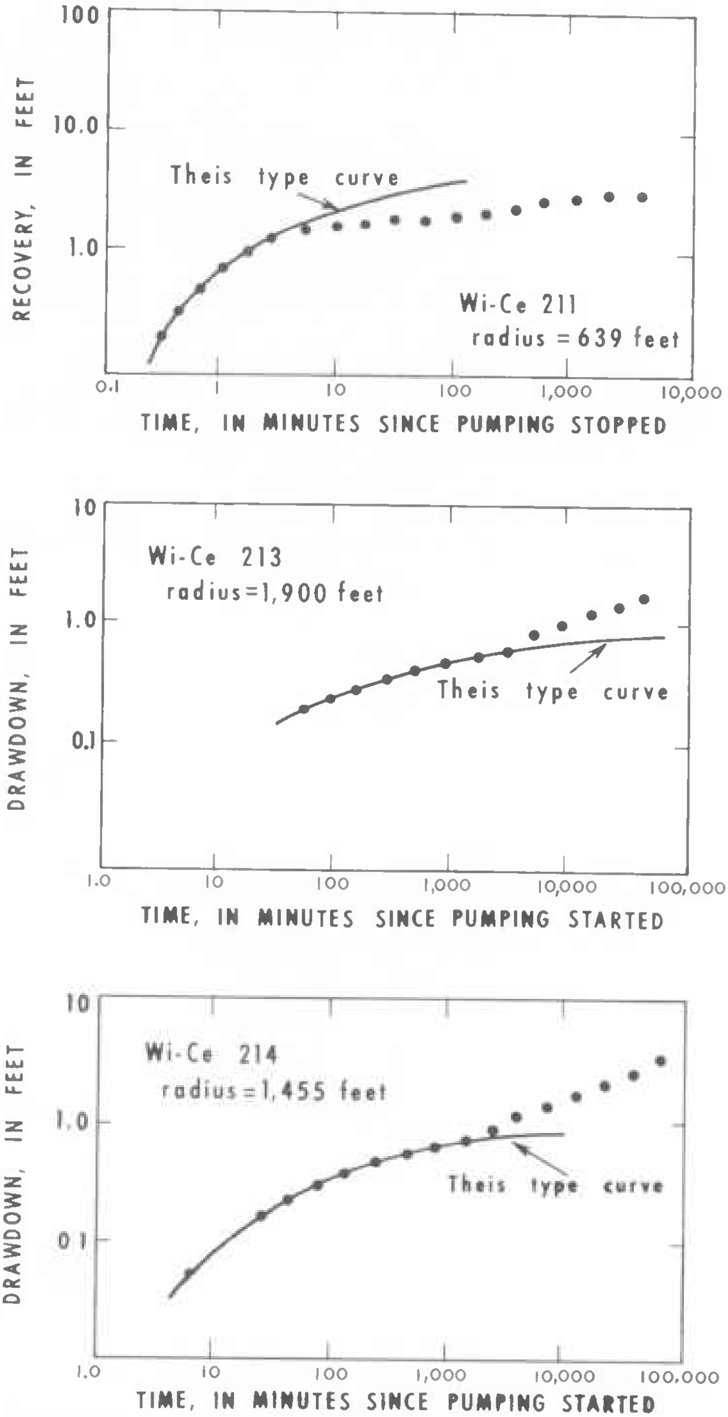
QUALITY OF WATER

The chemical quality of water pumped during the test was satisfactory for most uses with little or no treatment. The water in the aquifer is a sodium bicarbonate type with a dissolved-solids content ranging from 42 to 52 mg/l. (See table 5.) Samples were collected before the test began and periodically during the test to detect changes that might occur. The most significant change noted was that the iron concentration decreased from 0.46 mg/l on August 1 to 0.39 on October 3 and to 0.27 mg/l on October 18.

The chemical quality of water from well Wi-Ce 212, tapping the Manokin Formation, is similar to water pumped from the Salisbury Formation except for an excessive concentration of iron, 6.8 mg/l.

The quality of water flowing in Little Burnt Branch and the North Prong Wicomico River must be considered a very important factor when evaluating the aquifer. A large percentage of the water pumped from the aquifer during periods of heavy pumping will be derived from the nearby surface-water sources.

Water from Little Burnt Branch was higher in total dissolved solids than the water from the Salisbury Formation and had some color, but it was well within most limits for these items, as set by the U. S. Public Health Service. Concentrations of iron ranged from 0.31 to 0.73 mg/l, indicating that some treatment might be needed for its removal.



19. Log-log plots of drawdown or recovery versus time for wells Wi-Ce 211, 213, and 214.

TABLE 5. Chemical analysis of water from streams and wells at the pumping test site

(Chemical constituents in mg/l.)

Date of collection	Water Temperature		Silica (SiO_2)	Aluminum (Al)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue 180°C)	Hardness as $CaCO_3$		Specific conductance (micromhos at 25°C)	pH	Color
	°F	°C															Calcium, magnesium	Non carbonate			
Wi-Ce 200 (Salisbury Formation)																					
8-01-67	57	14	21	.	.46	0.02	1.9	0.5	5.2	1.6	10	5.0	3.8	0.0	2.0	50	7	0	48	5.7	5
10-03-67	..	..	21	..	.39	0.00	1.7	.4	5.0	1.3	10	4.2	3.3	.1	1.5	42	6	0	44	5.9	2
10-18-67	57	14	21	..	.27	0.00	1.6	.4	5.4	1.6	10	4.8	4.4	.1	1.1	51	6	0	47	7.0	..
Wi-Ce 204 (Salisbury Formation)																					
4-27-67	..	..	19	..	[1]	..	2.5	.3	5.3	1.4	12	.8	4.2	.0	4.1	52	7	0	71	5.97	5
Wi-Ce 212 (Manokin Formation)																					
11-17-67	57	14	26	..	6.8	.12	2.4	1.0	8.3	1.6	19	10	3.5	0	.3	..	10	0	68	6.8	..
Little Burnt Branch—Culver Pond																					
9-23-67	71	21.5	6.8	..	.73	.00	4.6	2.4	5.6	4.6	14	10	10	.3	1.4	80	22	10	85	6.0	80
Little Burnt Branch—Site 2																					
9-23-67	57	14	19	..	.31	.00	5.9	2.6	7.9	2.6	14	3.8	13.0	.1	13	90	25	14	103	6.4	30
North Prong Wicomico River—[2]																					
9-23-67	63	17	20	..	.45	.00	3.6	1.1	7.0	1.6	15	4.2	7.5	.2	4.2	62	14	1	68	6.4	20

[1] Fe^{+++} 0.04
Fe^{++} 0.16

[2] This site is described as North Prong, Wicomico River near Salisbury (Site 2) in Boggess and Heidel (1968).

Water from the overflow of Culver Pond was of a sodium chloride type with a dissolved-solids content of 80 mg/l. Water from site 2 on Little Burnt Branch was also a sodium chloride type with a dissolved-solids content of 90 mg/l. Water from the North Prong Wicomico River is a sodium bicarbonate type with a dissolved-solids content of 62 mg/l.

The quality of water in the aquifer after long periods of induced recharge from the streams would be influenced by the mixing of ground water and surface water. The filtering action of the sediments in the aquifer would be expected to remove much of the suspended solids and bacterial load of the induced surface water. However, monitoring of the quality of the streams would be important to warn of the presence of toxic or other contaminating substances that could be drawn into the aquifer.

The temperature of water pumped from well Wi-Ce 200 was 14°C throughout the 30 days of the test. Temperatures of Little Burnt Branch in table 6 were obtained on a random basis and ranged from 8.5 to 17°C during the period of this study. Variations noted were dependent largely on normal seasonal air temperatures modified because much of the water was ground water recently discharged from the aquifer at 14°C.

TABLE 6. Water temperature at site 2 on Little Burnt Branch.

Date	Hour	Temperature		Date	Hour	Temperature	
		°F	°C			°F	°C
September 19	0956	57	14	October 9	1147	61	16
19	1214	62.5	17	11	1057	58	14
19	1300	63	17	16	1312	59	15
19	2300	62.5	17	18	1836	61	16
20	0700	61	16	18	2220	57	14
21	0657	60	16	19	0301	56.5	13.5
21	1608	63	17	19	0708	54	12
22	0723	60	16	19	1000	55	13
22	1710	63	17	19	1421	56	13
23	0730	57	14	20	0720	51	11
23	1430	59	15	20	1500	53	12
25	1011	55	13	23	1157	53	12
26	0928	54	12	25	0959	57	14
27	1720	62	17	26	1004	53	12
28	0747	60	16	30	1455	52.5	11.5
30	1045	60	16	Nov. 3	0930	55	13
October 2	1118	55.5	13	8	1516	48	9
3	0721	55	13	13	1149	54	12
6	1055	62	17	17	1350	47.5	8.5

CONCLUSIONS

Under natural (nonpumping) conditions, the hydrologic situation in the vicinity of the pumping-test site is that of a relatively stable dynamic system in which an aquifer is discharging into a rather small, topographically low area. The aquifer contributes up to 7 cfs of ground water to the nearby streams, Little Burnt Branch and North Prong Wicomico River.

The aquifer test caused the hydraulic system to readjust itself to the stress of an artificially imposed discharge of 4,000 gpm. By the end of 30 days of pumping, the system was well adjusted to the new stress. The overall effect, which was not great, consisted mainly of the establishment of a new point of discharge, the pumping well, with a compensating reduction in natural discharge from the aquifer to the nearby streams.

Pumping affected the flow of Little Burnt Branch in two ways: (1) by decreasing the rate at which the aquifer discharged water into the stream and (2) by diverting water already in the stream through the streambed into the aquifer. North Prong Wicomico River was affected by a reduction in the rate of discharge from the aquifer into the stream, but it is probable that little, if any, water already in the stream was diverted into the aquifer.

Geologic and hydrologic data show that the explored part of the aquifer has a reservoir capacity in excess of 7 billion gallons, of which at least half can probably be withdrawn by wells. Rates at which water may be withdrawn by several large-capacity wells probably exceed the recharge rate of the aquifer. The large natural storage capacity of the aquifer will be an important factor in water-supply planning because it will reduce the capacity of surface storage needed to supply peak demands.

Lowering of water levels in the aquifer by heavy pumping will cause some lateral movement of water from surrounding areas and will reduce somewhat the quantities of water currently discharged to the atmosphere by evapotranspiration. The potential for salvage from evapotranspiration was not evaluated by this test.

Streams near the test site favor the production of large quantities of ground water by insuring a large continuous source of recharge to the aquifer. Because this test was made at a site in the discharge area of the aquifer and because the site is close to streams capable of supplying much water to the aquifer, the results of the test cannot be considered representative of the entire length of the channel-fill deposits. Well sites farther from the streams would induce less recharge from the streams and the sustained availability of ground water would be dependent more on local recharge to and storage in the aquifer.

The degree to which pumping from the aquifer affected Little Burnt Branch indicates that a good hydraulic connection exists between that stream and the aquifer. However, differences in water-level declines in zone A and B show that the vertical permeability of materials separating the streams and the aquifer is much lower than the horizontal permeability of zone B. The average rate of infiltration through the bed of the stream was about 30 gpd per square foot under the hydraulic gradients existing during the later parts of the test. No comparable determination was made for the streambed of North Prong Wicomico River.

Inducing water from streams carries the hazard of contaminating the aquifer with undesirable substances that might be carried in the streams. The limitation on the surface-water source is indicated by the mean annual discharge of the North Prong Wicomico River, 35 mgd, measured at Naylor Mill Road. Damming of the North Prong Wicomico River at Naylor Mill Road would facilitate movement of water into a heavily pumped aquifer by increasing hydrostatic head differentials and by enlarging the area of possible infiltration. However, increased siltation might impede water movement into the aquifer.

The long-term or sustained yield of the aquifer can be determined only after a long period of pumping and cannot readily be determined by a 30-day pumping test. The use of the best value of the coefficient of transmissivity (400,000 gpd per foot) and an estimated value of coefficient of storage to calculate future pumping levels at higher pumping rates would provide hypothetical and questionable results. During long-term pumping, the yield of the aquifer will depend upon the amount of infiltration induced from the nearby streams, the amount of natural discharge captured, and the amount of water salvaged by reduction in evapotranspiration.

Adoption of a policy of gradual development of the aquifer accompanied by close observation of the effects of pumping on ground-water levels and streamflow would provide much-needed data regarding the aquifer's capabilities and limitations. Such data would not only reveal the availability of many millions of gallons of water per day but also would forestall the possibility of constructing more wells than the aquifer can supply.

Selected References

Boggess, D. H., and Heidel, S. G., 1968, Water resources of the Salisbury area, Maryland, Maryland Geol. Survey, Rept. Inv. 3, 69 p.

Boulton, N. S., 1954, Unsteady radial flow to a pumped well allowing for delayed yield from storage: Internat. Assoc. Sci. Hydrology, Pub. 37, p. 472-477.

CARDWELL, W. D. E., and JENKINS, E. D., 1963, Ground-water geology and pump irrigation in Frenchman Creek basin above Palisade, Nebraska: U. S. Geol. Survey Water-Supply Paper 1577, 472 p.

HANSEN, H. J., 1966, Pleistocene stratigraphy of the Salisbury area, Maryland and its relationship to the lower Eastern Shore: A subsurface approach: Maryland Geol. Survey, Rept. Inv. 2, 56 p.

HANTUSH, M. S., and JACOB, C. E., 1955, Non-steady radial flow in an infinite leaky aquifer: Am. Geophys. Union Trans., v. 36, no. 1, p. 95-100.

MOORE, J. E., and JENKINS, C. T., 1966, An evaluation of the effect of groundwater pumpage on the infiltration rate of a semipervious streambed: Water Resources Research, v. 2, p. 691-696.

NORRIS, S. E., and FIDLER, R. E., 1969, Hydrogeology of the Scioto River Valley near Piketon, south-central Ohio: U. S. Geol. Survey Water-Supply Paper 1872, 70 p.

RASMUSSEN, W. C., and SLAUGHTER, T. H., 1955, The water resources of Somerset, Wicomico, and Worcester Counties: Maryland Dept. Geology, Mines and Water Resources Bull. 16, 533 p.

RASMUSSEN, W. C., and ANDREASEN, G. E., 1959, Hydrologic budget of the Beaverdam Creek Basin, Maryland: U. S. Geol. Survey Water-Supply Paper 1472, 106 p.

REED, J. E., DEUTSCH, M., and WIITALA, S. W., 1966, Induced recharge of an artesian glacial-drift aquifer at Kalamazoo, Michigan, U. S. Geol. Survey Water-Supply Paper 1594-D, 62 p.

RORABAUGH, M. I., 1956, Ground water in northeastern Louisville, Kentucky, with reference to induced infiltration: U. S. Geol. Survey Water-Supply Paper 1360-B.

THEIS, C. V., 1935, The relation between the lowering of the piezometric surface and the rate and duration of discharge of a well using groundwater storage: Am. Geophys. Union Trans. pt. 2, p. 519-524.

THEIM, GUNTHER, 1906, Hydrologische methoden (Hydrologic methods): Leipzig, J. M. Gebhardt, 56 p.

WALTON, W. C., HILLS, D. L., and GRUNDEEN, G. M., 1967, Recharge from induced steambed infiltration under varying groundwater level and steam-stage conditions, Water Resources Research Center, Univ. of Minnesota, Bull 6, 42 p.

WEEKS, E. P., 1969, Determining the ratio of horizontal to vertical permeability by aquifer-test analysis: Water Resources Research, v. 5, p. 196-214.

WEEKS, E. P., ERICSON, D. W., and HOLT, C. L. R., 1965, Hydrology of the Little Plover River basin, Portage County, Wisconsin and the effects of water resource development; U. S. Geol. Survey Water-Supply Paper 1811, 78 p.

APPENDIX

This appendix presents supporting basic data for preceding interpretive sections of the report. It includes geophysical logs, drillers' logs, and other general information available for the 27 wells and test holes used in the study.

Table 7. Records of wells and test holes at or near the pumping test site. (Supplements Table 1 in Boggess and Heidel, 1968)

Geological Survey well number Wi-	State permit number	Owner or name	Driller	Date completed	Altitude (feet) Measuring pt.	Altitude (feet) Land surface	Type of well	Depth (feet)	Diameter of well (inches)	Depth of screen below land surface (feet)	Total screen length (feet)
Be 28	67-37	L. G. Culver & Sons, Inc.	Ideal Well Drillers	1966	38.83	38	Drilled	217 T 100 C	4	92-100	8
Ce 195	------	City of Salisbury	--------	1967	20.25	16	do	8	2-C 1-1/4S	7-8	1.5
Ce 196	------	do	--------	1967	16.75	16	do	7	1-1/4S	6-7	1.5
Ce 197	------	do	--------	1967	20.18	16	do	7	1-1/4S	6-7	1.5
Ce 198	67-191	do	Layne-Atlantic Co.	1967	-----	34.6	do	199	-------	------	---
Ce 199	67-191	do	do	1967	-----	30.7	do	207	-------	-------	---
Ce 200	67-195	do	do	1967	29.96	28.7	do	160	26-C 16-S	80-160	80
Ce 201	67-191	do	do	1967	-----	21.5	do	248	------	------	---
Ce 202	67-191	do	do	1967	-----	37.9	do	202	------	------	---
Ce 203	67-191	do	do	1967	-----	34.6	do	248	------	------	---
Ce 204	67-191	do	do	1967	31.61	28.5	do	306 T 119 C	8-C 3-S	109-119	10
Ce 205	------	do	-------	1967	22.39	17.68	Augured & driven	7	2-C 1-1/4S	6-7	1.5
Ce 206	------	do	-------	1967	17.82	15	do	7	1-1/4S	6-7	1.5
Ce 207	------	do	-------	1967	18.57	15.5	do	7		6-7	1.5
Ce 208	------	do	-------	1967	22.23	19.7	do	7	1-1/4S	6-7	1
Ce 209	67-284	Deer's Head Realty Corp.	Ideal Well Drillers	1967	42.30	42.5	Drilled	170 T 140 C	2-C 2-S	132-140	8
Ce 210	67-285	City of Salisbury	do	1967	41.10	39	do	150 T 132 C	4-C 2-S	122-132	10
Ce 211	67-286	do	do	1967	25.11	23	do	128 T 122 C	4-C 2-S	112-122	10
Ce 212 A	67-287	Deer's Head Realty Corp.	do	1967	38.33	36	do	200 T 175 C	4-C 2-S	165-175	10
Ce 212 B	67-287	do	do	1967	38.33	36	do	20 C	2-C 2-S	18-20	2
Ce 213 A	67-288	J. Wm. Brittingham Estate	do	1967	39.99	38	do	260 T 157 C	4-C 2-S	147-157	10
Ce 213 B	67-288	do	do	1967	39.99	38	do	40 C	2-C 2-S	38-40	2
Ce 214 A	68-44	Wicomico County	do	1967	43.89	42	do	120 T 115 C	4-C 2-S	105-115	10
Ce 214 B	68-44	do	do	1967	43.89	42	do	40 C	2-C 2-S	38-40	2
Ce 215	------	City of Salisbury	-------	----	38.85	39	do	43 C	1-1/4	------	--
Ce 216	67-114	Deer's Head Realty Corp.	M. P. Brittingham	1966	36	36	do	303	-----	None	--
Cf 147	------	W. F. Allen Co.	Middletown Well Drilling Co.	1964	41.73	40.8	do	285 T 80 C	2	60-80	20

Depth: T, depth drilled for testing; C, depth of bottom of well after completion
Diameter of well: C, casing diameter; S, screen diameter
Pumping equipment: N, none; T, turbine
Remarks: (a) geophysical logs available; (b) chemical analysis available; (c) observation well; (d) core samples collected.

Water-bearing formation or unit	Water level (feet below measuring point)			Pumping equipment	Yield		Specific capacity (gpm/ft.)	Remarks	Geological Survey well number Wi-
	Static	Pumping	Date		Gallons per minute (gpm)	Date			
Salisbury Fm.	9.5	40	8-22-66	-	50	8-02-66	1.7	(a), (c)	8e 28
do	3.29	--------	9-18-67	N	----	--------	---	(c)	Ce 195
do	.13	--------	9-18-67	N	----	---------	---	(c)	Ce 196
do	2.76	--------	9-18-67	N	----	---------	---	(c)	Ce 197
do	------	---------	--------	N	----	---------	---	Probe hole no. 1; (a); (d)	Ce 198
do	------	---------	--------	N	----	---------	---	Probe hole no. 2; (a)	Ce 199
do	10.05 ------	--------- 34.28	9-18-67 10-18-67	T	4,000	9-18-67	154	Production well for pump test; (b)	Ce 200
do	------	---------	--------	N	----	--------	---	Probe hole no.3; (a)	Ce 201
do	------	---------	--------	N	----	--------	---	Probe hole no.4; (a)	Ce 202
do	------	---------	--------	N	----	--------	---	Probe hole no.5; (a)	Ce 203
do	9.42	12.86	4-27-67	T	162	4-27-67	47	Probe hole no.6; (a); (b); (c); (d)	Ce 204
do	------	---------	--------	N	----	--------	---	(c)	Ce 205
do	------	---------	--------	N	----	--------	---	(c)	Ce 206
do	------	---------	--------	N	----	--------	---	(c)	Ce 207
do	------	---------	--------	N	----	--------	---	(c)	Ce 208
do	23.90	---------	9-18-67	N	----	--------	---	(a); (c)	Ce 209
do	21.52	---------	9-18-67	N	----	-------	---	(c)	Ce 210
do	3.68	---------	9-18-67	N	----	-------	---	(c)	Ce 211
Manokin aquifer	18.70	24.45	11-17-67	N N	----	11-17-67	6	(a); (c)	Ce 212 A
Salisbury Fm.	19.46	---------	9-18-67	N	----	-------	---	(c)	Ce 212 B
do	20.25	---------	9-18-67	N	----	-------	---	(a); (c)	Ce 213 A
do	20.28	---------	9-18-67	N	----	-------	---	(c)	Ce 213BB
do	21.60	---------	9-18-67	N	----	--------	---	(c)	Ce 214 A
do	21.49	---------	9-18-67	N	----	--------	---	(c)	Ce 214 B
do	------	---------	-------	N	----	--------	---	(c)	Ce 215
--------------	16	---------	12-11-67	N	42	12-11-67	3	Probe hole	Ce 216
do	16.86	---------	9-18-67	N	----	--------	---	Observation well	Cf 147

TABLE 8. Drillers' logs of wells and test holes.

Lithology	Thickness (feet)	Depth to base (feet)
Wi-Ce 198 (Altitude 35 feet)		
Sand, brown	5	5
Clay, white	7	12
Sand, coarse, white and thin; layers of white clay	8	20
Sand, coarse, brownish	30	50
Gravel and coarse sand, brown	10	60
Sand, coarse, brown	10	70
Gravel, coarse, and sand	10	80
Gravel and coarse sand	10	90
Sand and coarse gravel	10	100
Gravel and sand, brown	10	110
Sand, coarse and tan	30	140
Gravel and tan sand	5	145
Gravel, pea size, reddish	5	150
Gravel and sand, coarse, reddish	5	155
Sand and small gravel, reddish	5	160
Sand and gravel, coarse, reddish	5	165
Clay, gray; and tan sand, mixed	5	170
Clay, gray; and grayish sand, in layers	5	175
Sand, coarse, clean, grayish; and thin layers of wood	20	195
Wi-Ce 199 (Altitude 31 feet)		
(No record 0-105)		
Sand, coarse, tan; and small gravel	50	155
Sand, very coarse, tan; and small gravel	10	165
Sand, medium coarse, tan	10	175
Sand, medium coarse, gray	7	182
Sand, medium coarse, gray; and thin layers of wood	5	187
Sand, coarse, gray; and thin layers of wood	4	191
Sand, light gray; and thin layers of wood	5	196
Sand, fine, gray	6	202
Sand, medium coarse and fine, gray	5	207
Wi-Ce 200 and 204 (Altitude 29 feet)		
Sand	14	14
Sand, coarse, brown	16	30
Sand, coarse, reddish; and some small gravel	20	50
Sand, coarse, reddish; and small gravel with a few layers of dry yellowish clay	10	60
Sand, very coarse, reddish, clean; and small gravel	10	70
Sand and pea sized gravel, brownish	10	80
Sand, and small gravel, brownish	10	90
Gravel, coarse; and brownish sand	10	100
Sand, very coarse, brownish; and small gravel	50	150
Sand, coarse, tan; and small gravel	10	160
Sand, coarse, tan; and gravel	3	163
Sand, fine, gray; and few layers of soft gray clay	7	170
Sand, medium coarse, gray; and few thin layers of clay	3	173
Sand, medium coarse to coarse, gray; and thin layers of gray clay and wood	7	180
Sand, coarse, gray; and wood with fine gray sand inter-mixed	10	190
Sand, coarse, gray, and few thin layers of gray clay	20	210
Sand, fine, and clay, gray, mixed	12	222
Clay, gray; and thin layers of fine gray sand	8	230
Clay, gray; silty sand; and fossil shells	20	250
Clay, soft gray; and fossil shells	20	270

TABLE 8. **Drillers' logs of wells and test holes**—(*continued*)

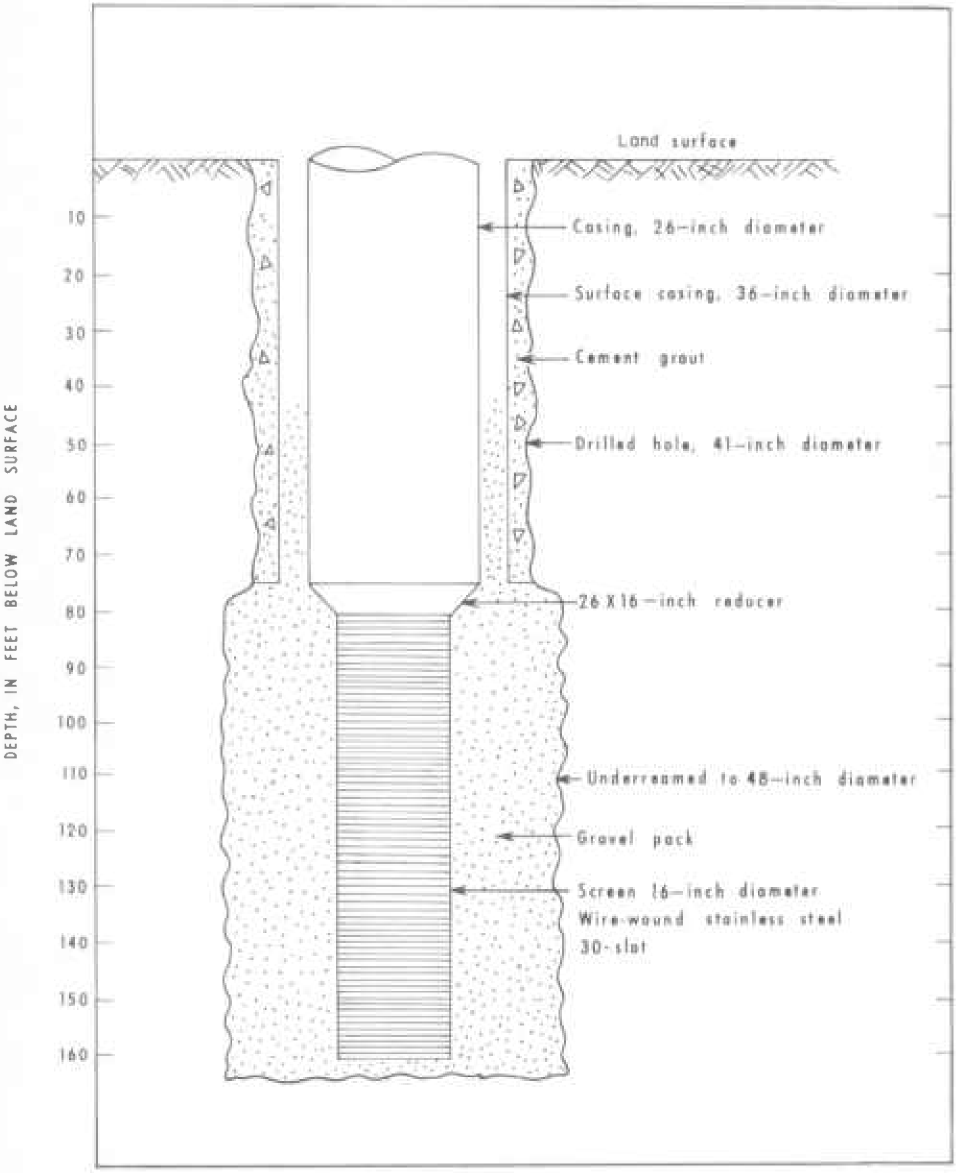
Lithology	Thickness (feet)	Depth to base (feet)
Clay, gray, and abundant fossil shells	30	300
Clay, gray; and fossil shells	2	302
Wi-Ce 201 (Altitude 21 feet)		
Sand, (fill)	1	1
Sand and layers of clay, white	9	10
Sand, medium to coarse, brownish	3	13
Sand, coarse, brown; and fine gravel	71	84
Sand, coarse, brown; and pea gravel	69	153
Sand and pea gravel, tan	13	166
Sand, coarse, tan; and coarse gravel; with thin layers of reddish clay	10	176
Gravel, coarse; and sand with thin layers of soft gray clay	10	186
Sand and fine gravel tan; with thin layers of gray clay	11	197
Sand, tight packed, tan; and few streaks of gray clay	8	205
Sand, fine, tan	12	217
Clay, gray, (no sample)	12	229
Clay, gray, and broken fossil shells	19	248
Wi-Ce 202 (Altitude 38 feet)		
Sand, yellow	2	2
Clay, hard, white	10	12
Sand, coarse, brown	8	20
Sand, coarse, white	4	24
Sand, coarse, reddish	19	43
Sand, coarse, reddish; and small gravel	41	84
Sand, reddish; and coarse gravel	61	145
Sand, coarse, tan; and small gravel	39	184
NOTE: drilling rods dropped from 184 to 192 feet, circulation of drilling mud was lost, and the remainder of the test hole was drilled dry (no sample)	8	192
Gravel and sand (inferred from manner in which drill cut; no sample collected)	10	202
Clay, gray	¼	202¼
Wi-Ce 203 (Altitude 35 feet)		
Sand, coarse, brown	45	45
Sand, coarse, brown; and fine gravel	39	84
Sand and coarse gravel	20	104
Sand, coarse, brown; and few thin layers of fine gravel	25	129
Sand, coarse, brown; and pea gravel	33	162
Lost circulation of drilling mud	1	163
Sand, medium to coarse, with some fine	28	191
Sand, coarse, gray	19	210
Sand, fine, gray	17	227
Sand, gray; and layers of soft sticky clay and fossil shells	17	244
Clay, gray, sticky; with fossil shell	4	248
Wi-Ce 209 (Altitude 42 feet)		
Clay with some silt and sand, light yellow brown	14	14
Clay, blue, (drilled slow)	6	20
Clay and sand, dark brown, organic	7	27
Gravel, fine (lowest 6 inches cemented with iron)	13	40
Sand and fine gravel in layers	10	50

TABLE 8. Drillers' logs of wells and test holes—(*continued*)

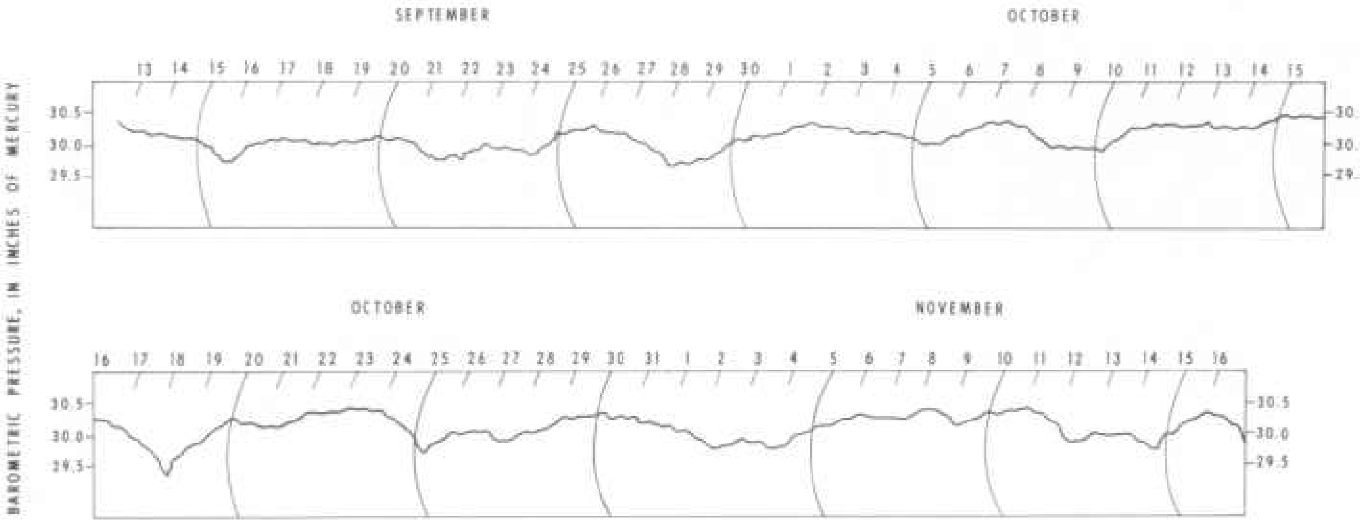
Lithology	Thickness (feet)	Depth to base (feet)
Sand, medium to coarse; with some gravel, light gray brown	10	60
Sand, medium to coarse, light gray brown	10	70
Sand, medium to coarse; with some gravel, light gray brown	40	110
Sand, coarse; and fine gravel, light yellow brown	10	120
Sand, medium to coarse; with fine gravel, light gray brown	10	130
Gravel, fine to medium	10	140
Sand, fine to medium, light gray and some brown	20	160
Sand, medium to coarse, dark gray; with some lignite	10	170
Wi-Ce 210 (Altitude 39 feet)		
Clay, light grayish yellow	10	10
Sand, fine to medium, dark brown	10	20
Sand, medium to coarse, light reddish brown	10	30
Sand, fine to medium, light reddish brown	10	40
Clay and sand, fine to medium, light reddish brown	10	50
Clay with sand, fine to medium, light reddish brown	10	60
Clay and sand, fine to medium, light reddish brown	10	70
Sand, medium to coarse, light reddish brown	10	80
Sand, fine to medium, with some silt and clay, light reddish brown	10	90
Sand, medium to coarse, light grayish brown	10	100
Sand, fine to coarse, light grayish brown	20	120
Sand, medium to coarse, light grayish brown	30	150
Wi-Ce 211 (Altitude 23 feet)		
Sand, fine to medium; with some clay; light gray	10	10
Sand, fine to coarse; with gravel; reddish brown	10	20
Sand, fine to coarse, reddish brown	50	70
Sand, medium to coarse, and fine gravel, reddish brown	58	128
Wi-Ce 212 (Altitude 36 feet)		
Sand, fine to coarse, and gravel, with silt and clay, light gray	10	10
Sand, medium to coarse, light tan	40	50
Sand, medium to coarse, with some fine sand and gravel, light tan	10	60
Sand, fine, and silt, light yellow tan	8	68
Sand, fine to medium, with clay, silt, and gravel, dark reddish tan	10	78
Clay, with little silt, blue gray	2	80
Clay, blue, in streaks, with sand fine to medium, gray	10	90
Sand, fine to medium, gray	8	98
Clay, drilled very slow	2	100
Sand, fine, with some medium, gray	10	110
Sand, fine, gray	40	150
Sand, medium to coarse, gray	10	160
Sand, medium to coarse; some gravel, gray	10	170
Sand, fine to medium, gray	10	180
Sand, very fine to medium, olive gray (drilled much slower)	10	190
Sand, very fine to medium, olive gray (drilled very slow)	10	200

TABLE 8. Drillers' logs of wells and test holes—(*continued*)

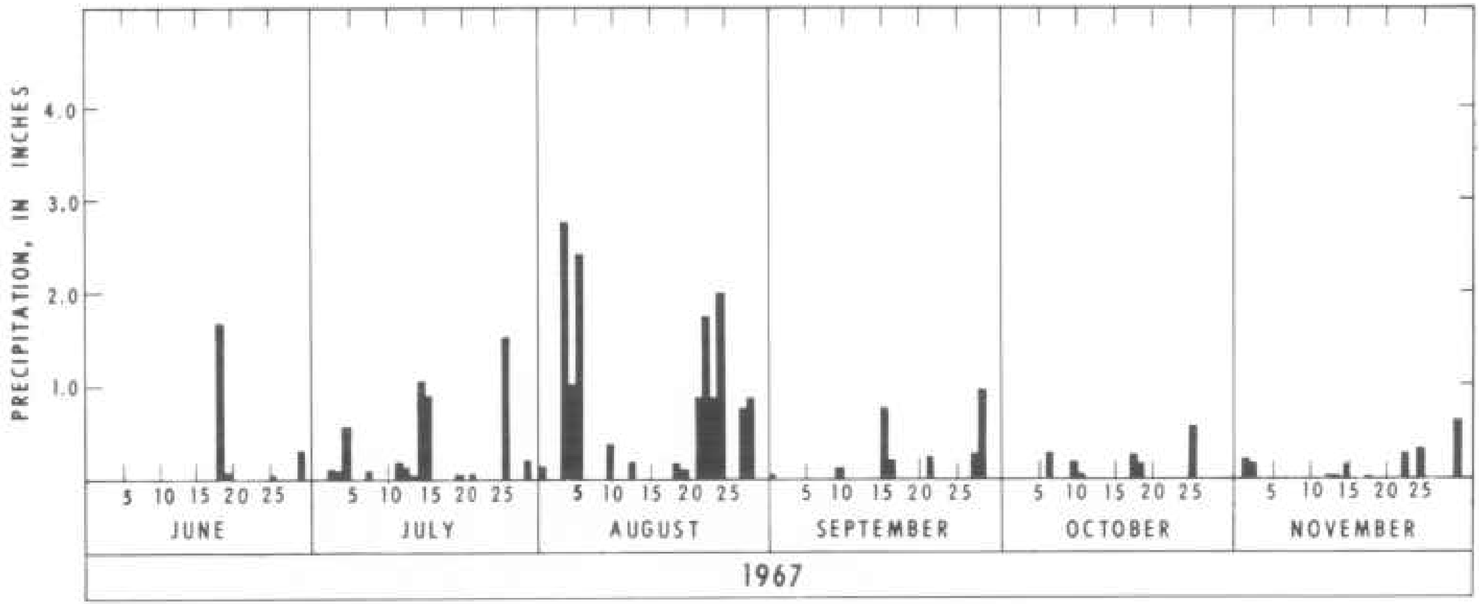
Lithology	Thickness (feet)	Depth to base (feet)
Wi-Ce 213 (Altitude 38 feet)		
Sand	2	2
Clay, gray	15	17
Clay, gray, layered with reddish brown sand and gravel	17	34
Clay, gray, layered with greater percentage of reddish brown sand and gravel than the interval from 17-34	6	40
Silt; sand from fine to coarse; and gravel; reddish brown	10	50
Sand, fine; with some medium sand and silt; reddish brown	10	60
Gravel and sand, coarse to medium, reddish brown	10	70
Gravel and sand, coarse to medium, ten	30	100
Gravel and sand, coarse to fine, tan	30	130
Gravel and sand, coarse, tan	40	170
Gravel and sand, coarse to fine, tan	10	180
Similar to interval from 170 to 180 but possibly with some blue clay	17	197
Clay, blue, very hard	2	199
Sand, fine, brownish gray, with some clay and silt	21	220
Clay with silt and fine sand, gray brown	20	240
Clay, some silt, blue (drilled fast)	10	250
Clay, blue (drilled fast)	10	260
Wi-Ce 214 (Altitude 42 feet)		
Clay, with silt and fine sand, grayish brown	10	10
Clay with silt and fine sand, gray	10	20
Sand, from fine to coarse; with some silt, clay, and gravel; reddish brown	10	30
Sand, medium, with some fine and some coarse, yellow gray	10	40
Sand, fine, medium, and coarse; with some silt and gravel; reddish brown	20	60
Sand, medium to coarse, dark reddish brown	10	70
Sand, medium and coarse; with some fine sand and gravel, reddish brown	20	90
Gravel and sand, coarse, with some medium, reddish brown	10	100
Sand, medium to coarse; with some fine sand and gravel, reddish brown	20	120
Wi-Ce 216 (Altitude 36 feet)		
Topsoil	2	2
Clay and gravel	3	5
Gravel and sand, white	7	12
Sand and gravel, yellow	12	24
Sand and gravel, orange	6	30
Clay and sand, yellow	3	33
Sand and gravel, yellow	27	60
Sand and wood	12	72
Sand and gravel, orange	6	78
Clay and wood, blue	7	85
Sand, fine, and gray clay	35	120
Clay and sand, green and gray	10	130
Sand, clay, and wood, gray	55	185
Gravel, medium, white, and wood	30	215
Clay and fine sand, gray	88	303



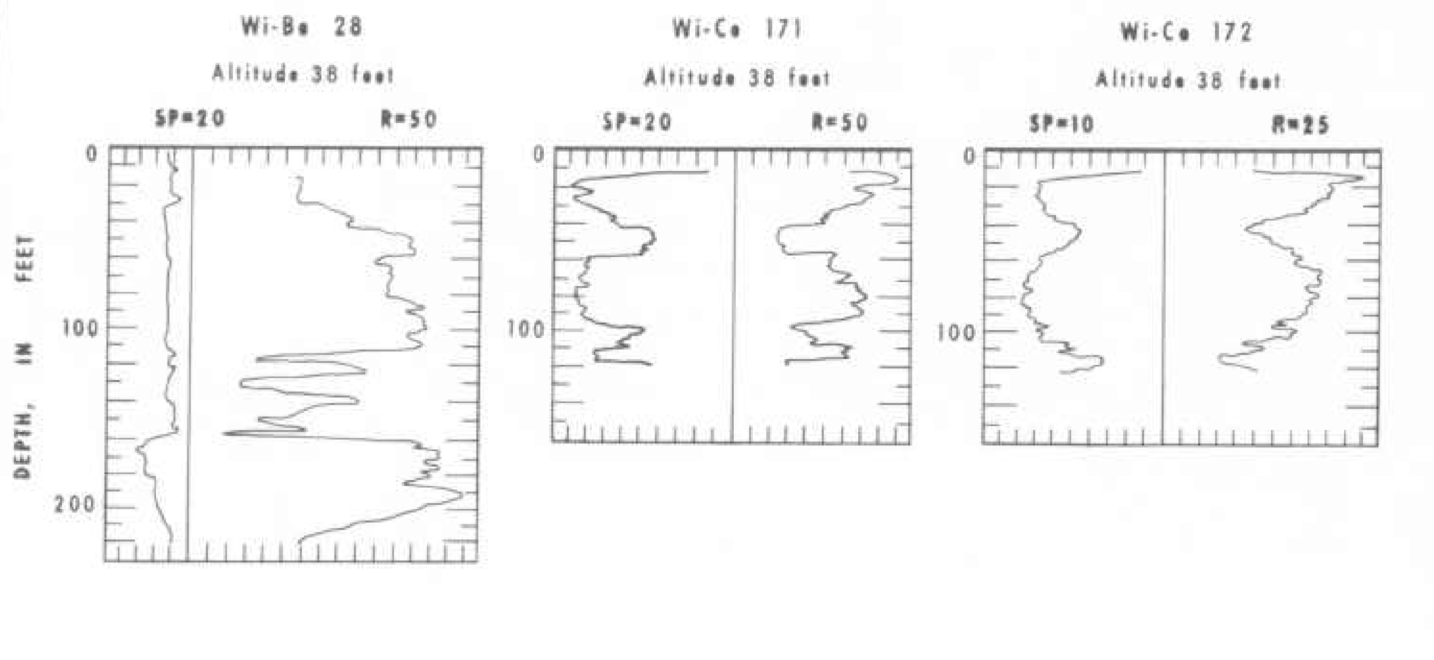
20. Sketch showing details of construction for well Wi-Ce 200, production well for the pumping test.



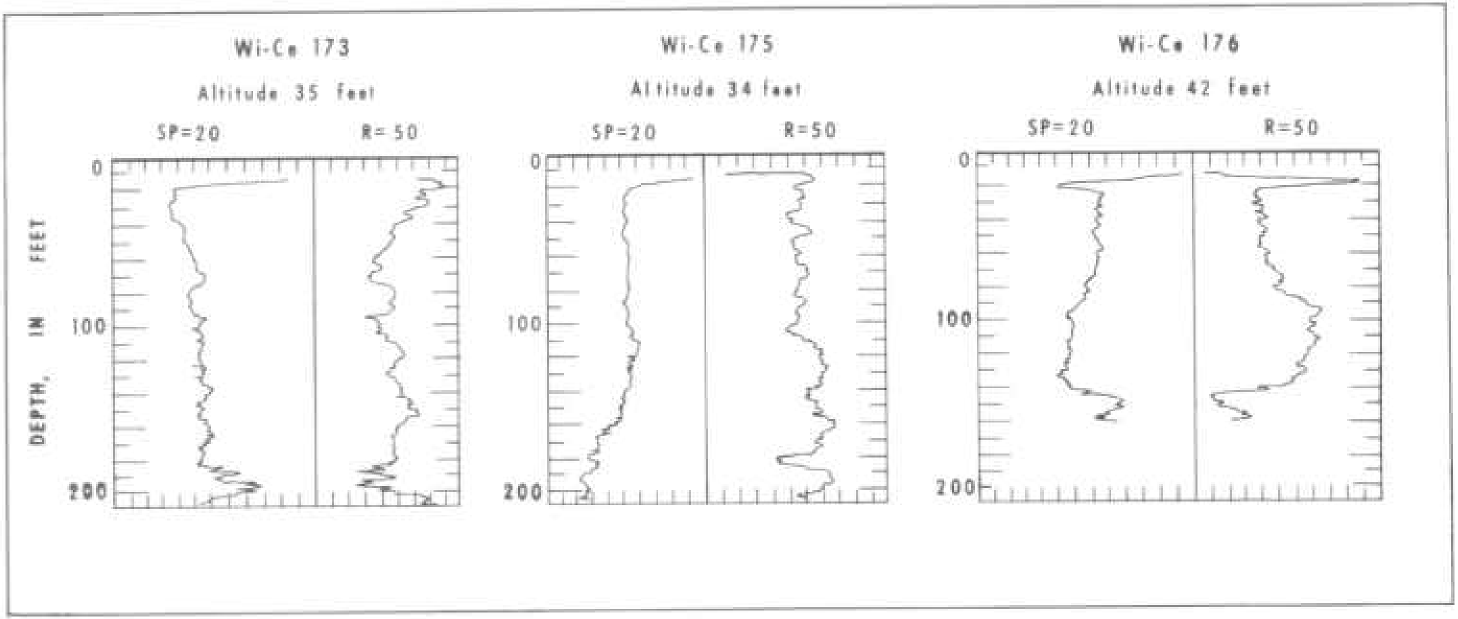
21. Graph of barometric pressure at the test site during the pumping test.



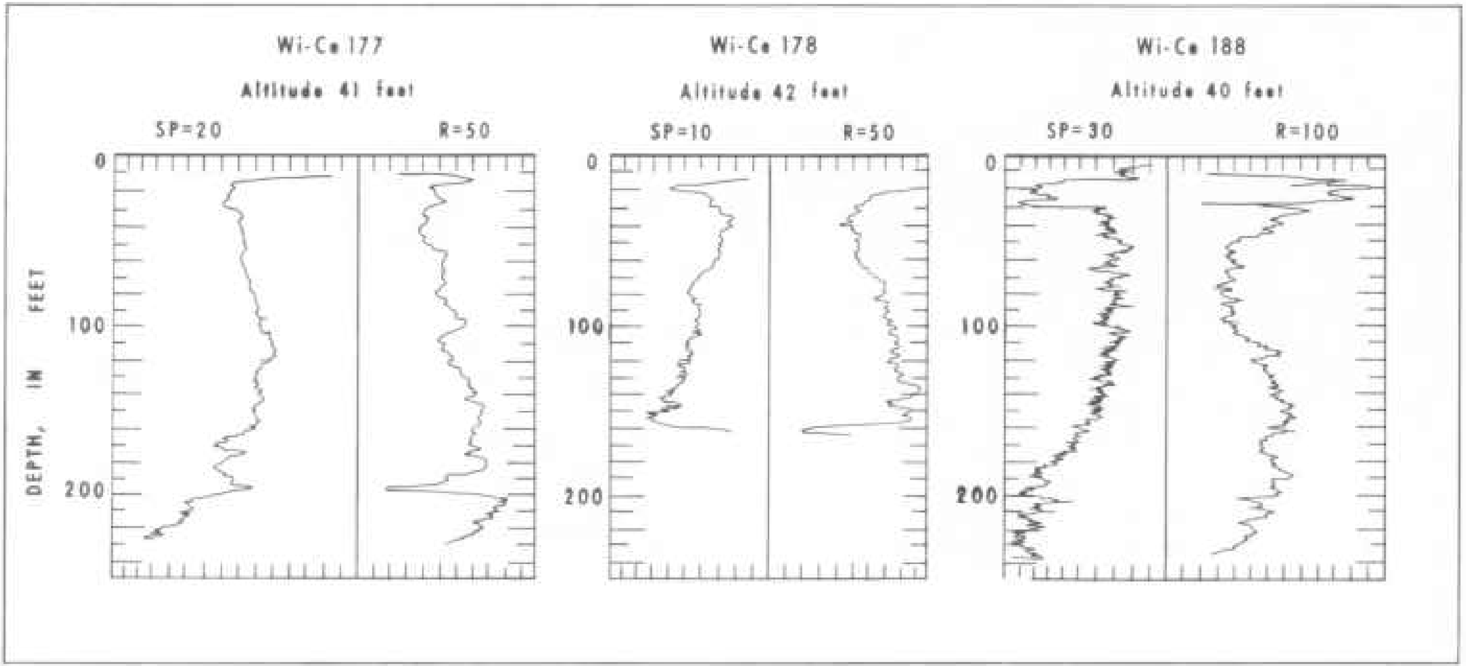
22. Graph of precipitation in the city of Salisbury during the pumping test.



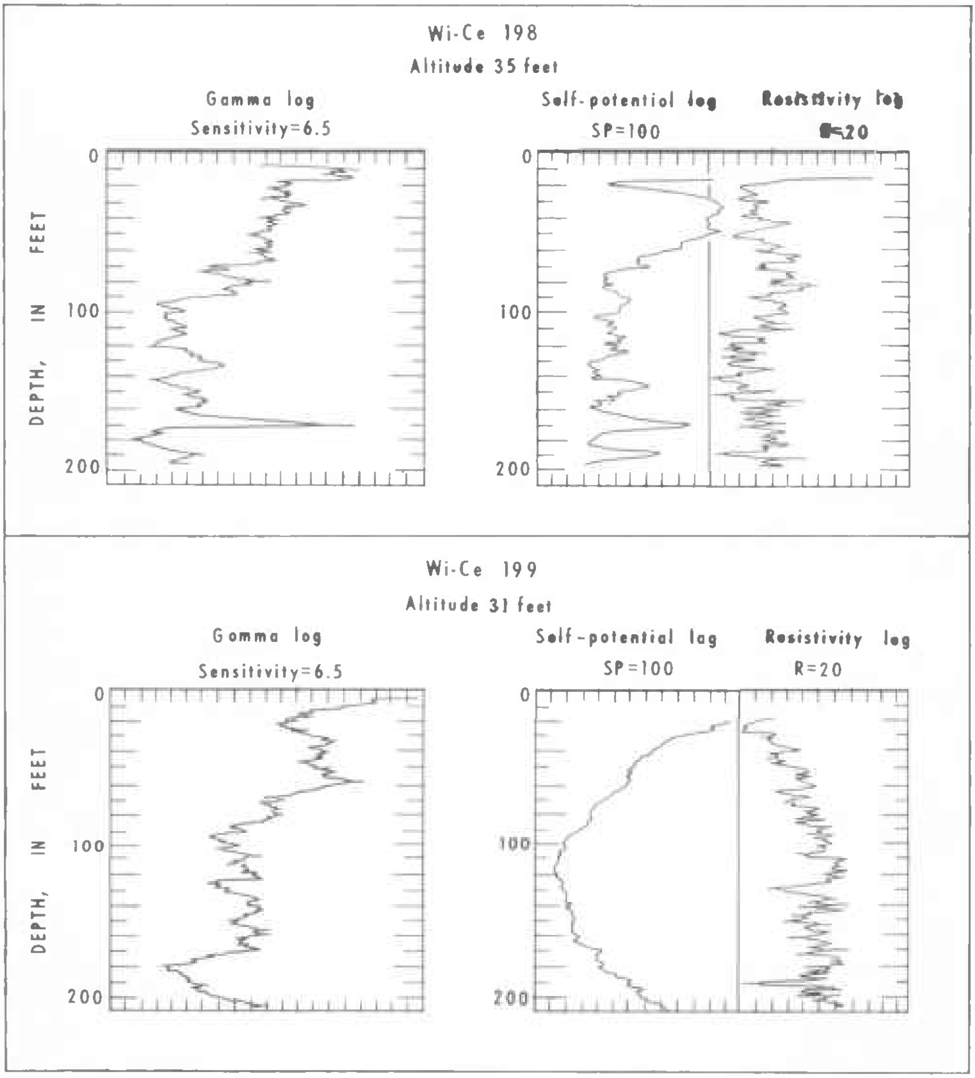
23. Geophysical logs for wells Wi-Be 28, Wi-Ce 171, and Wi-Ce 172.



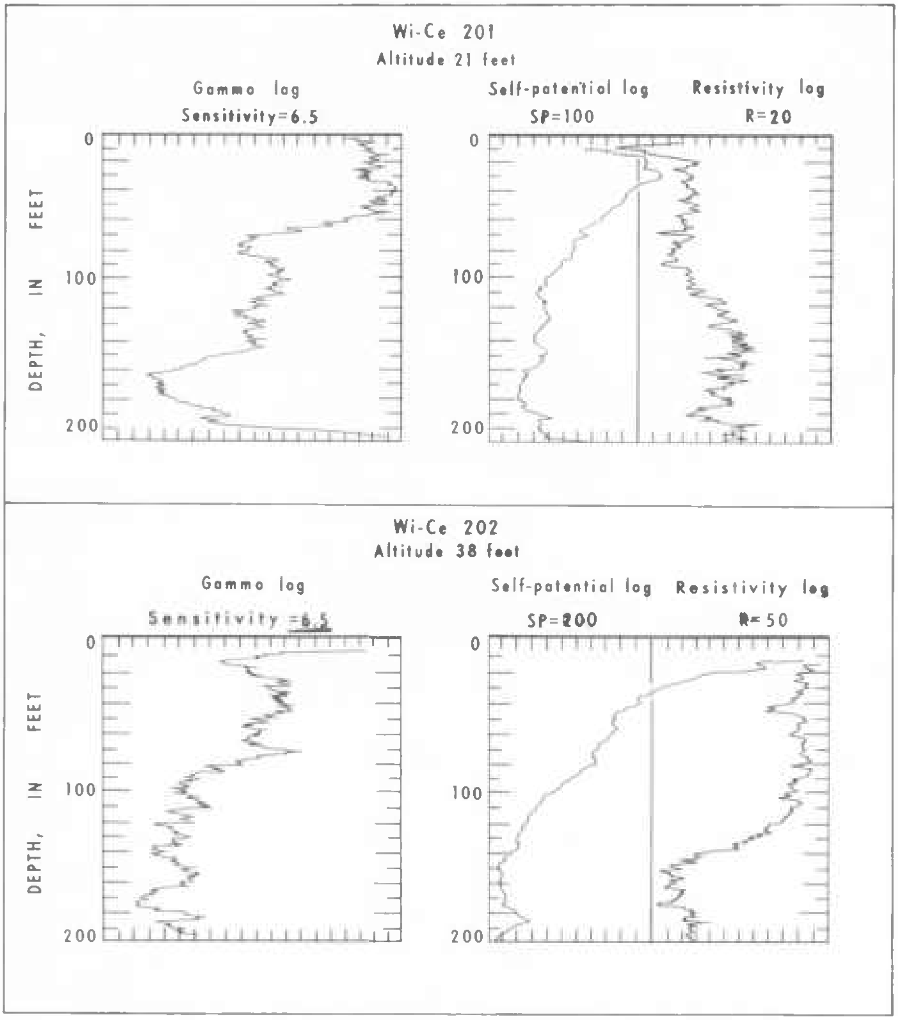
24. Geophysical logs for wells Wi-Ce 173, 175, and 176.



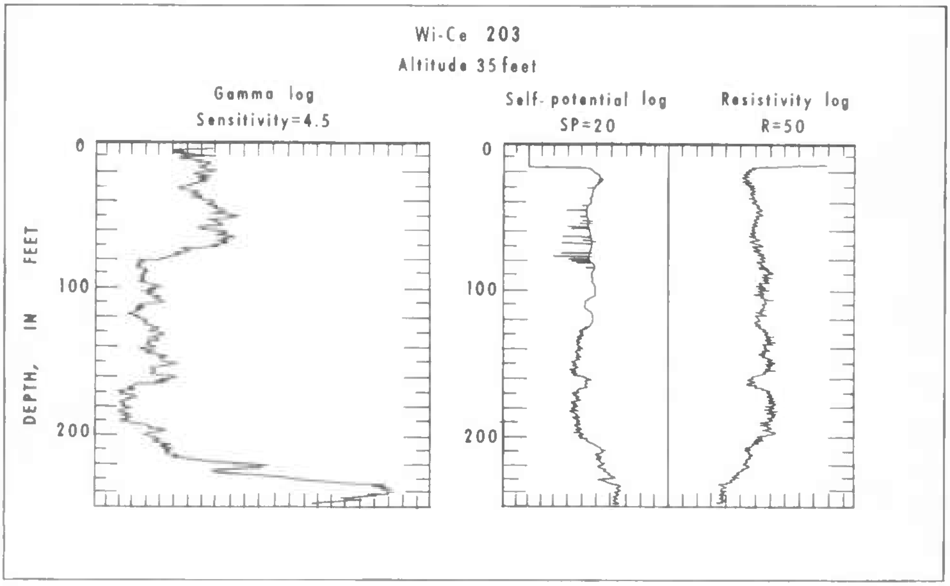
25. Geophysical logs for wells Wi-Ce 177, 178, and 188.



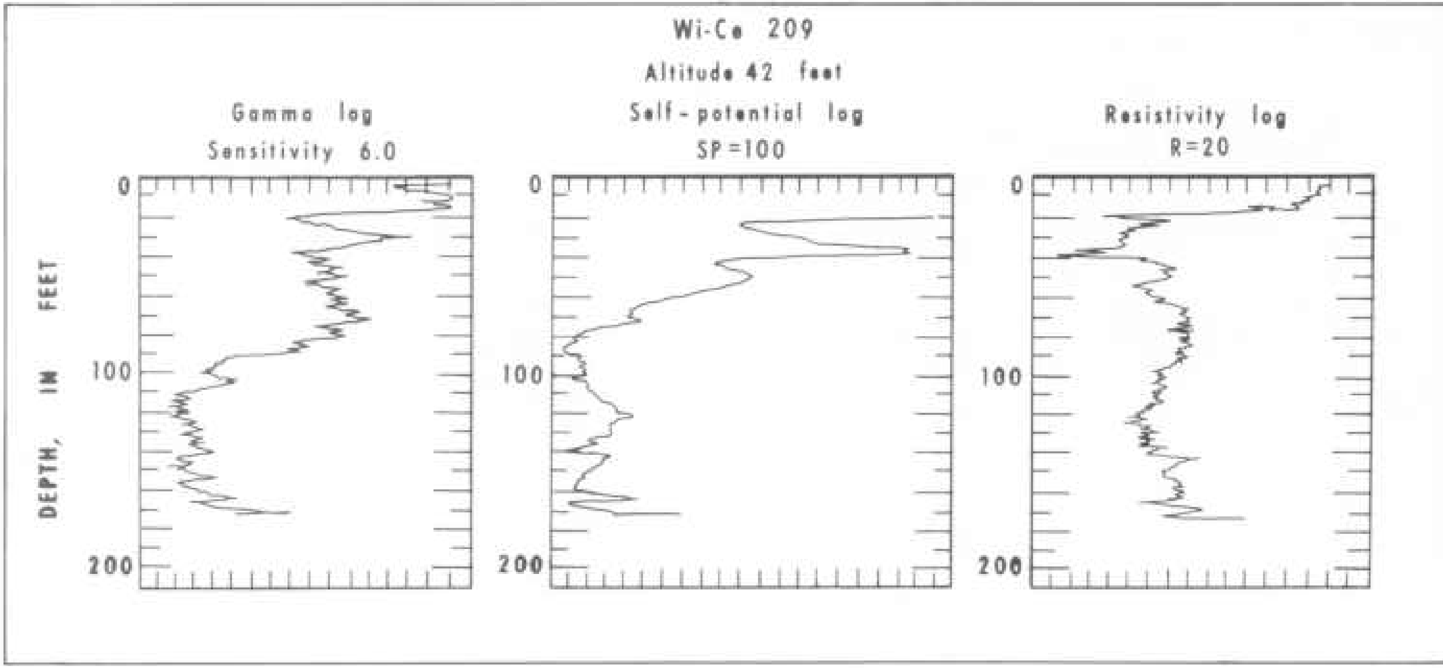
26. Geophysical logs for wells Wi-Ce 198 and 199.



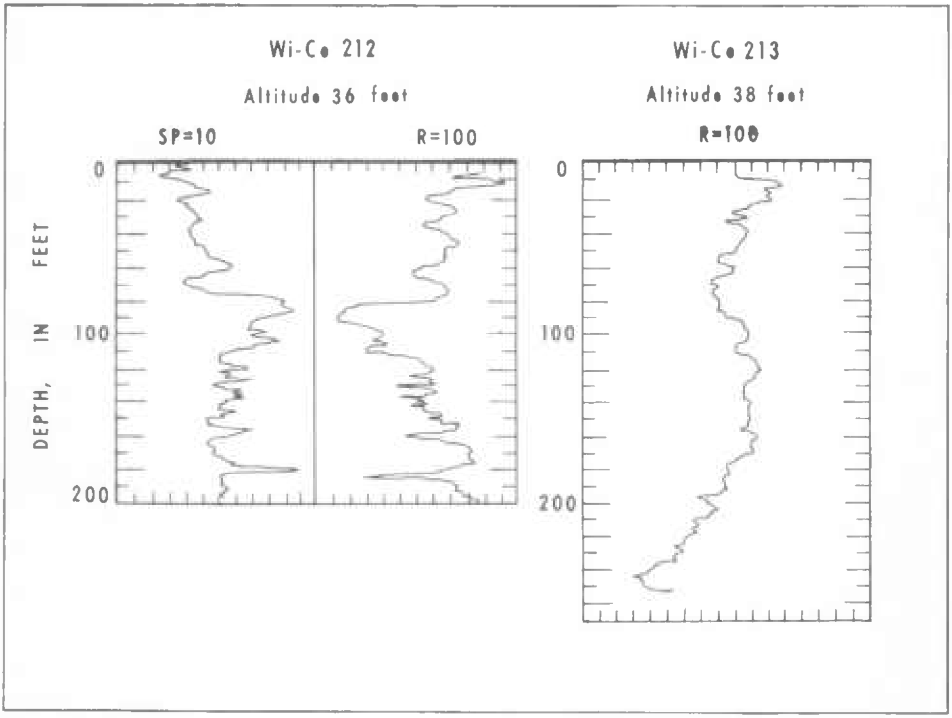
27. Geophysical logs for wells Wi-Ce 201 and 202.



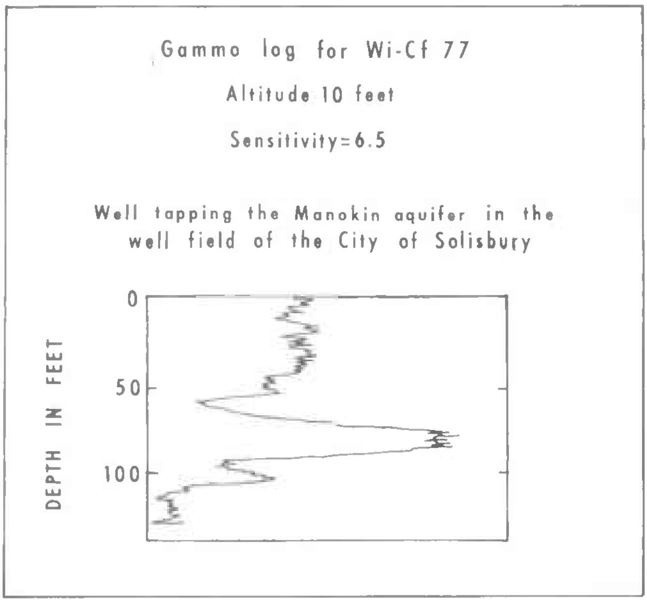
28. Geophysical logs for well Wi-Ce 203.



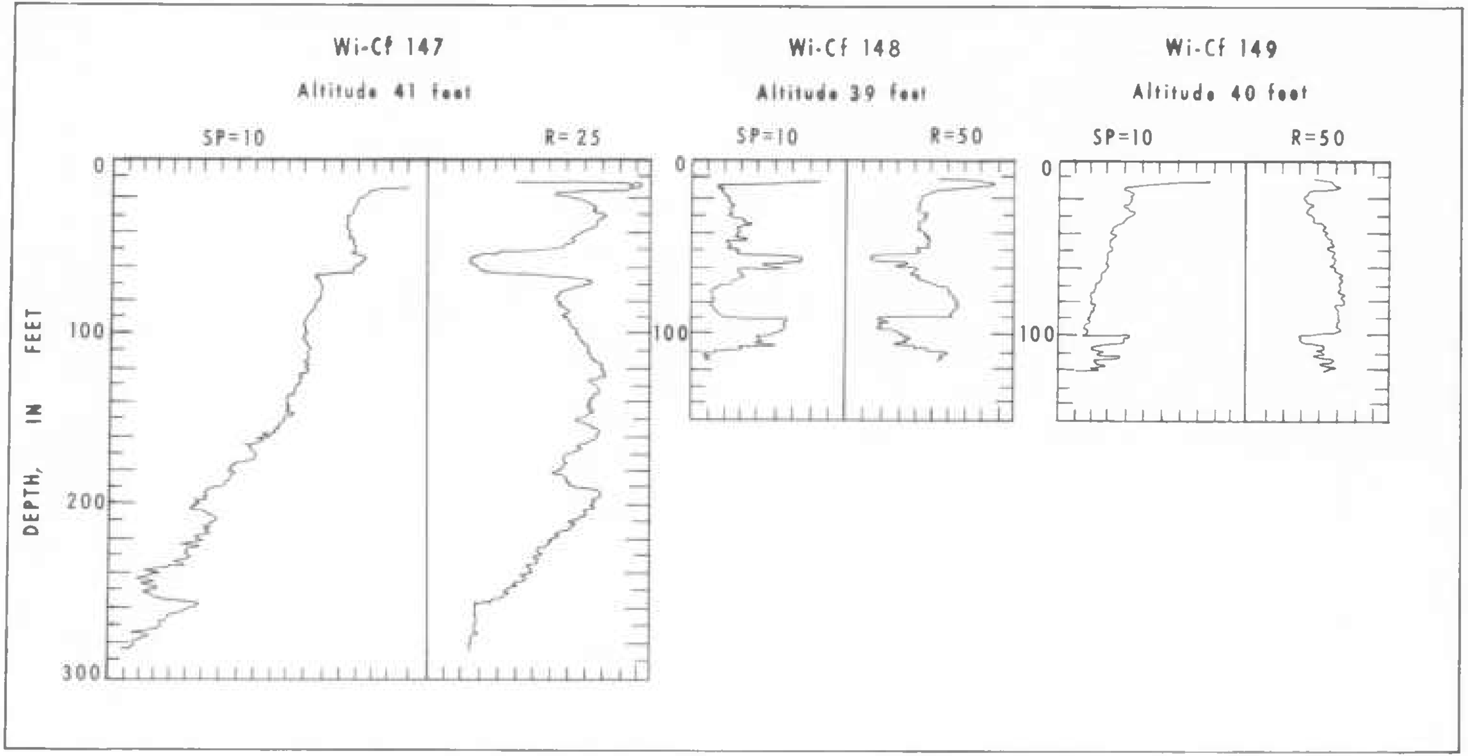
29. Geophysical logs for well Wi-Ce 209.



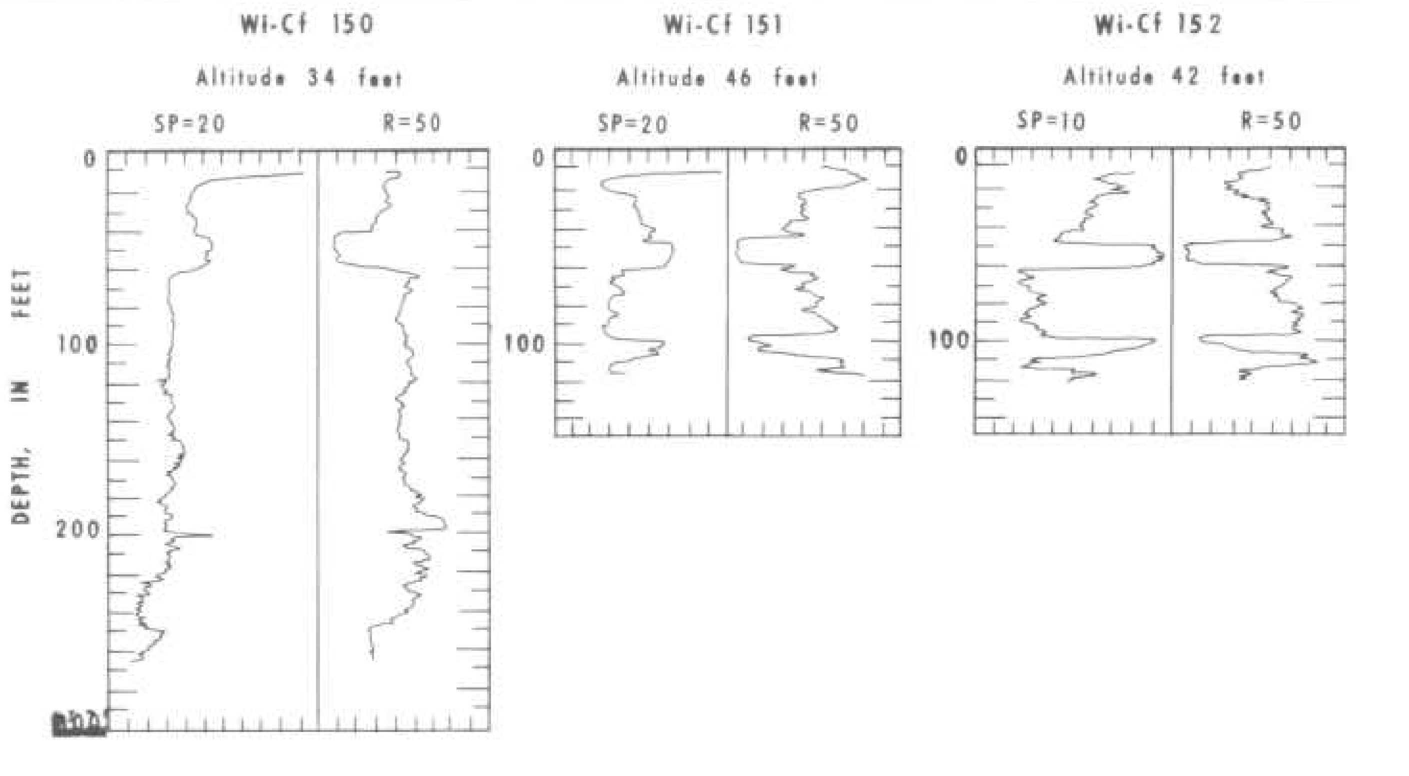
30. Geophysical logs for wells Wi-Ce 212 and 213.



31. Geophysical log for well Wi-Cf 77.



32. Geophysicol logs for wells Wi-Cf 147, 148, and 149.



33. Geophysical logs for well Wi-Cf 150, 151, and 152.

BULLETIN 31

PART 2

EXPLORATION AND MAPPING OF SALISBURY PALEOCHANNEL, WICOMICO COUNTY, MARYLAND

By
JAMES M. WEIGLE
U. S. Geological Survey

ABSTRACT

The Salisbury paleochannel is a buried valley. It was carved into an erosional plain at the top of the Miocene deposits and was filled and blanketed subsequently by deposits (mostly sand and gravel) of Pleistocene age.

The channel deposits are a prolific source of ground water. Large amounts of water are stored there. More important, the saturated Pleistocene deposits in the channel offer up to twice the drawdown available in the adjacent Pleistocene deposits outside the channel and therefore require fewer wells to yield equal quantities of water. Because of the greater available drawdown the channel and its deposits could drain ground water from the adjoining Pleistocene materials and the underlying Manokin aquifer.

The bottom of the paleochannel is a depression in the Miocene-Pleistocene contact surface. The channel was located by mapping the Miocene-Pleistocene contact topographically along the presumed channel direction by power-augering and gamma-logging through hollow drill-stem. Once the contact was identified along the flanks the deep, central parts of the channel could be explored with a few test holes drilled by conventional methods. This technique, which made maximum use of the power auger, proved to be relatively fast, inexpensive, and flexible.

The Salisbury paleochannel extends into Wicomico County from eastern Dorchester County, crossing beneath the Nanticoke River near Vienna. From there it trends generally east-southeastward to the vicinity of U. S. Route 13, about 2 miles northeast of Salisbury, where it apparently shallows and becomes distributary. Its total mapped length is more than 20 miles.

The part of the paleochannel known prior to this study (north of Salisbury) is about a half to a third of a mile wide. To the west and northwest the paleochannel widens abruptly; it attains a width of about 1 mile and an incised depth of about 120 feet (a cross-sectional area of about half a million square feet) 2 miles northeast of Hebron.

The stream that cut the buried valley flowed generally east-southeastward. From near the southwest corner of Delaware to U. S. Route 13 the stream cut down through a confining layer (the lower aquiclude), generally transected the Manokin aquifer, and bottomed near the top of the more resistant St. Marys Formation of Miocene age. Undermining of the valley walls by lateral stream erosion and ground-water sapping may have caused extensive slumping, thereby accounting for the relatively great width of the buried valley northeast of Hebron; the constriction to the east (down-valley) may be related to greater resistance of the materials in the Manokin aquifer there.

ABSTRACT—Continued

East of U. S. Route 13 the coarse channel deposits may thin eastward under a thickening wedge of estuarine silts and clays or interfinger with them, in response to a worldwide rise in sea level during the time the channel deposits were being laid down.

Possibly, but much less likely, the channel originally dog-legged northward in the vicinity of U. S. Route 13 and thence eastward; landslides from the western wall of the valley may have blocked the northward-trending segment of the channel and deflected the streamflow eastward.

INTRODUCTION

The U. S. Geological Survey in cooperation with the Maryland Geological Survey conducted an exploratory study of the gravel-filled, buried channel north and west of Salisbury, Md., during 1966-70.

The channel deposits are recognized as a potential source of large quantities of ground water. This study, although primarily exploratory, was an integral part of the overall investigation of the quantities and quality of water available in the channel deposits. The objectives were to further map the extent and shape of the channel where it might occur in the index area shown in figure 1 and, simultaneously, to test techniques for more rapid location and mapping of such features.

This report describes and evaluates the exploratory techniques tested during the mapping. It describes what is now known about the shape and extent of the channel and possible relations to similar features nearby and briefly discusses the hydrologic implications. The summary includes suggestions for further study to answer questions that arose during the investigation.

The report is intended as an aid in planning for the future of the water-resources in central and western Wicomico County. Knowledge of the extent and shape of the channel gained during the investigation is presented as a basis for future study of its hydrology. The experience gained in exploratory techniques is presented as being applicable to additional similar mapping locally or elsewhere.

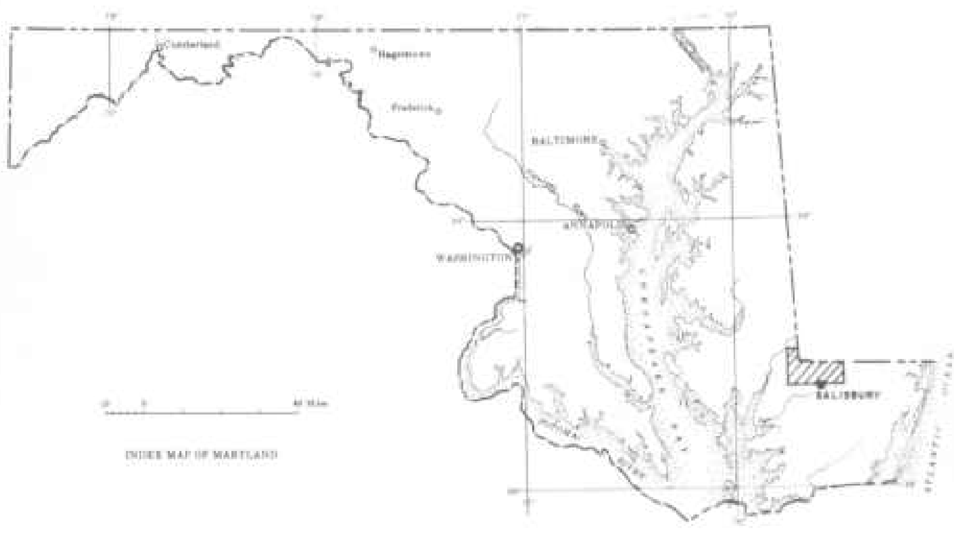


Figure 1. Map showing location of area described in this report.

Previous Investigation

In 1947 R. R. Meyer and R. R. Bennett conducted the first detailed investigation of the ground-water resources of the Salisbury area. The results were included as a special section titled "Ground-water resources of the Salisbury area" in a report on the water resources of Somerset, Wicomico, and Worcester Counties by Rasmussen and Slaughter (1955).

The Salisbury paleochannel was discovered in 1963 by investigators from the U. S. Geological Survey and the Maryland Geological Survey during a cooperative study of the water resources of the Salisbury area. H. J. Hansen (1966) described the Pleistocene stratigraphy and geologic history of the Salisbury area and mapped a section of the channel 2 miles long (fig. 2). D. H. Boggess and S. G. Heidel, in their report on

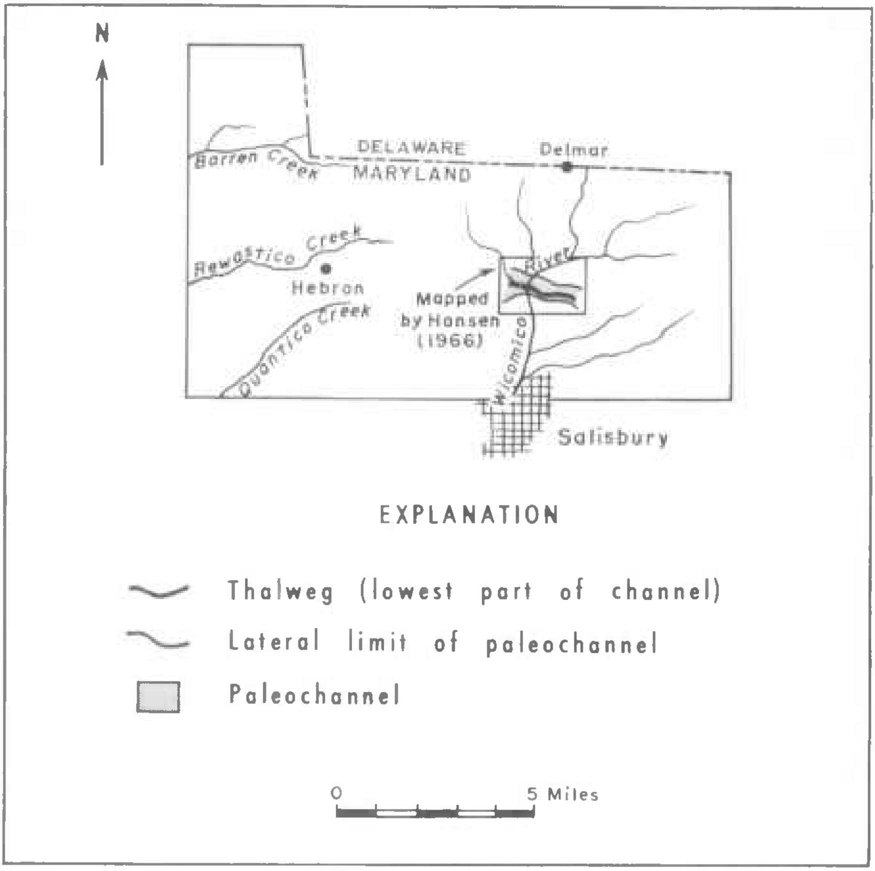


Figure 2. Map showing location of paleochannel mapped by H. J. Hansen in 1966.

the water resources of the Salisbury area (1968), determined the geohydrologic characteristics of that part of the channel. Both reports were based on an investigation conducted during 1963-65 by the U. S. Geological Survey in cooperation with the Maryland Geological Survey and the city of Salisbury. In 1967 Mack and Thomas (part 1 of this bulletin) determined characteristics of the paleochannel aquifer north of Salisbury by a 30-day pumping test.

The report by Hansen (1966) was taken as the starting point for this study.

Acknowledgments

The author is indebted to the Wicomico County Department of Public Works and to the individual land owners whose cooperation made possible the collection of most of the data in this report. Thanks are expressed to the many well owners and well drillers who provided much of the background information for the report.

The valuable advice and assistance rendered by H. J. Hansen, Geologist, Maryland Geological Survey, is gratefully acknowledged.

THE SALISBURY PALEOCHANNEL

The Salisbury paleochannel (including the Naylor Mill paleochannel of Hansen, 1966) is a former stream valley, filled with sand and gravel and buried under yet more sand and gravel. In places it is several thousand feet wide, and the bottom lies as much as 250 feet below land surface.

Geologic Setting

The Salisbury area is veneered by windblown fine sand and silt of Holocene age, underlain by Pleistocene deposits generally from 75 to 100 feet thick, that disconformably overlie Miocene deposits (fig 3). Locally the Miocene strata dip southeastward about 11 feet per mile. Table 1 describes the geologic units in the channel area and their water-bearing characteristics. The breakdown of geologic units in table 1 and elsewhere in this report varies slightly from that used by Mack and Thomas (part 1 of this bulletin) to describe a small part of the area covered in this report.

The materials of Pleistocene age, with the exception of the Walston Silt and the sea-level clay, are predominantly sand and fine gravel of generally tan, orange, red, brown, or yellowish color. The Walston Silt occurs at the top of the Pleistocene deposits in most of the area. It is from 0 to 20 feet thick and is composed of interbedded clay, silt, and sand; it varies considerably in average grain size and permeability.

Beneath the Walston Silt lies the Salisbury aquifer (Hansen, 1966) consisting of two lithofacies that are distinctive in some places. The uppermost is the Beaverdam Sand—tan or gray-white sand and fine gravel. The lowermost is the red gravelly facies—orange-brown or red-brown sand and fine gravel. Materials in the red gravelly facies are generally somewhat coarser than those in the Beaverdam Sand.

A lens of sticky pink-brown and light-gray clay as much as 30 feet thick occurs locally in the Pleistocene deposits, near the top of the red gravelly facies, at about sea level. It is referred to as the sea-level clay of Pleistocene age.

The materials in the lower aquiclude (that part of the Miocene deposits directly underlying the Pleistocene deposits in most of the area studied) are primarily silt, clay, and fine sand and include small pockets of black or brown peat, wood, or lignite. Most of the clay and silt is medium to very dark gray or blue gray, although some is green and purple. Generally, the sand is white or gray, but lenses or beds of orange or rusty-red partly cemented sand and gravel occur also.

The Manokin aquifer (also of Miocene age, and directly beneath the lower aquiclude) is mostly well-sorted fine, medium, or coarse gray sand and some fine gravel.

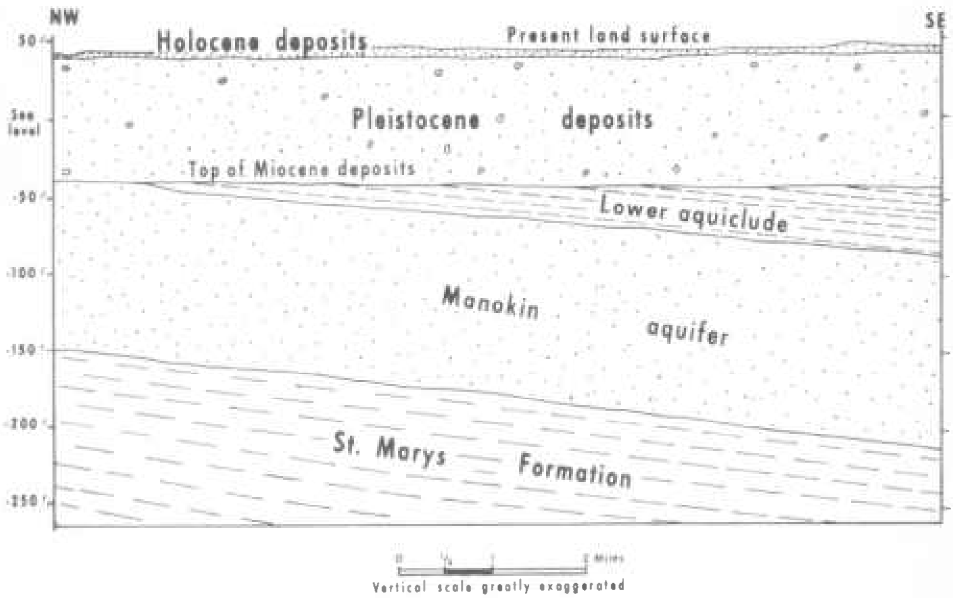


Figure 3. Diagrammatic section southeastward across area described, showing dip of Miocene deposits.

Table 1. Geologic units in the channel area and their lithologic and water-bearing characteristics.

Series	Geologic unit		Hydrologic unit	Thickness (feet)	Lithologic character	Water-bearing properties 2/
Holocene (Recent)	--		--	0 - 10	Sand, fine-grained, tan, windblown; mantles interfluvial areas; 0 - 10 feet thick.	Commonly unsaturated, but permits water to percolate downward to underlying units.
Pleistocene	Walston Silt		Aquiclude	0 - 20	Interbedded clay, sandy to silty and sand, fine to medium-grained, very clayey, mottled gray to tan; tidal marsh deposit.	Leaky confining bed above Salisbury aquifer.
	Salisbury aquifer	Beaverdam Sand	Aquifer	5 - 70	Sand, coarse; brown, tan or white; and some clay.	Capable of yielding large quantities of water, but less prolific than red gravelly facies.
		Red gravelly facies	Aquifer	30 - 195	Sand, very coarse, and gravel; orange-brown or red-brown; upper part includes lens of tan or gray clay up to 30 feet thick north of Salisbury (fig. 15).	Unit of greatest permeability. Yielded 4,000 gpm of water from one well for 30 days (Mack and Thomas, Part I of this Bulletin).
Miocene	Yorktown Formation(?)		Lower aquiclude	0 - 50	Clay, silt, and sand, very fine to fine; dark gray or blue-gray; rarely fossiliferous. Absent in extreme northwestern part of project area.	Where it occurs, generally confines the top of the Manokin aquifer.
			Manokin aquifer	0 - 130	Sand, fine to coarse; gray.	Yields small to moderate quantities of water. Flowing wells are common at altitudes less than 25 feet above mean sea level.
	St. Marys Formation		Aquiclude	70 - 140	Clay, "sticky", silt and sand, very fine to fine; dark gray; very fossiliferous.	Generally unproductive of water in this area. Confines the base of the Manokin aquifer.

1/ The nomenclature is that of the Maryland Geological Survey and does not necessarily agree with that of the U.S. Geological Survey.

2/ "Small" indicates yields of 5-25 gpm; "moderate", 25-300 gpm; "large", over 300 gpm.

The lower aquiclude pinches out westward, beveled by the old erosion plain at the present top of the Miocene deposits. As a result the Pleistocene deposits rest directly on the Manokin aquifer in the western part of the area.

Evolution

The sequence of events that formed the paleochannel is shown diagramatically in figure 4. Initially the channel was carved by a stream that traversed an erosional surface on the Miocene deposits. The channel was cut through the lower aquiclude into the underlying Manokin aquifer and locally into the St. Marys Formation. Later, Pleistocene alluvial and estuarine materials filled the channel and buried the preexisting Miocene surface and the channel to a depth of 75 to 100 feet. Thus, although the Pleistocene deposits are of fairly consistent thickness outside the channel, they are thicker along the channel itself.

The geologic history during Pleistocene time is described in detail by Hansen (1966, p. 18-23), who states that the red gravelly facies was probably deposited by braided streams and the Beaverdam Sand probably by estuarine waters. Hansen also suggests (1966, p. 21-22) those facies were deposited contemporaneously until late in deposition when the Beaverdam Sand completely transgressed the red gravelly facies.

The red gravelly facies is overlain by the Beaverdam Sand in the Salisbury area and thins eastward and southward beneath the compensatively thickening Beaverdam.

EXPLORATORY METHODS

This study was concerned with mapping the geometry of the channel, namely its course and its cross-sectional shape. To do this it was essential to distinguish the Pleistocene from the Miocene deposits. The course of the channel was mapped by determining those locations where the base of the Pleistocene deposits is deepest, and the cross-sectional shape of the channel was determined by contouring the base of the Pleistocene deposits.

Geologic Basis For Exploratory Technique

The following basic assumptions were made and diagnostic characteristics utilized in developing an exploratory technique to define the geometry of the channel:

(1) The surface at the base of the Pleistocene deposits (and the top of the Miocene deposits) is relatively flat except along the course of the channel, where it is a troughlike depression.

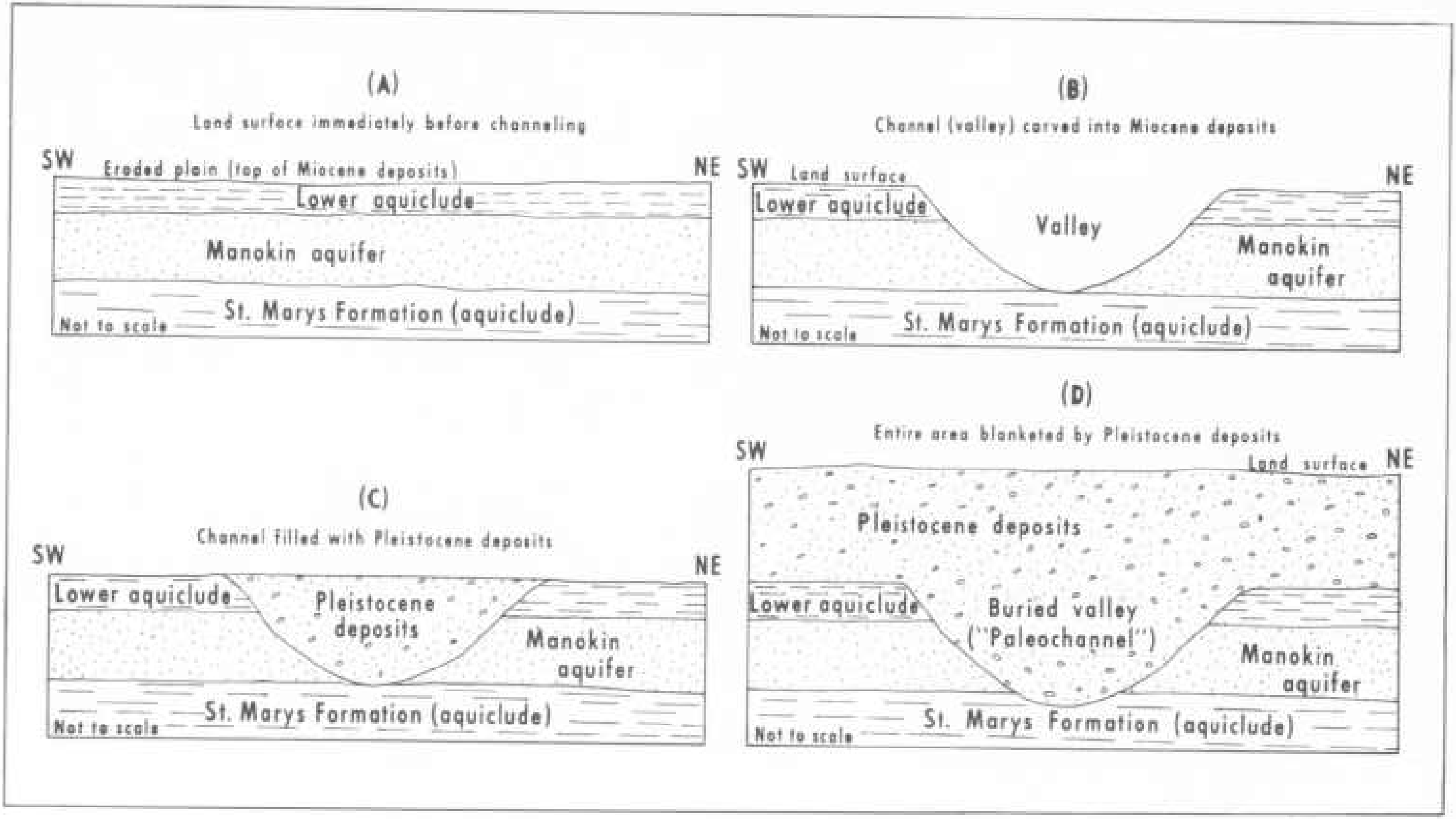


Figure 4. Diagrammatic cross sections showing evolution of paleochannel.

(2) Except in the channel, the Pleistocene-Miocene contact occurs at about 50 feet below sea level (or about 100 feet below land surface), and therefore is attainable by power augering.
(3) The flanks of the channel are attainable by power augering, although the bottom is beyond the depth limits of the auger.
(4) The Pleistocene and Miocene units can be distinguished by characteristic shapes of gamma-ray logs, as well as on the basis of color, grain size, degree of sorting, and presence or absence of lignite as follows:
    (a) The Miocene materials are generally light gray to very dark gray; the Pleistocene materials generally are tan, yellow, brown, or orange.
    (b) Materials in the Pleistocene deposits are generally coarser grained and less well sorted than those in the Miocene deposits.
    (c) The lower acquiclude in the Miocene deposits commonly includes very dark gray or blue-gray, sticky, lignitic clay; where clay occurs in the Pleistocene deposits, it is usually light gray or tan. Outside the part of the channel mapped previously the lower aquiclude directly underlies the Pleistocene deposits; within the channel, it is missing.

Power-Auger Gamma-Logging Technique

The technique that was developed, tested, and utilized in this exploration was a combination of methods. It was developed in response to specific conditions near that part of the channel mapped previously, and was modified appropriately elsewhere as mapping progressed.

The procedure was to drill test holes with a power auger and make gamma-ray logs through hollow drillstems. Three types of information were obtained thereby: (1) the "feel" and sound of the auger in operation, which provides a rough indication of the lithologies penetrated, (2) the gamma-ray log (fig. 5), and (3) cutting samples returned by the auger or adhering to the bit. In most cases, this information was enough to permit ready identification of the top of the Miocene deposits.

The depth of the contact between the Pleistocene and Miocene deposits outside the channel is predictable within a few feet. Therefore, the test holes were augered 10 to 20 feet deeper than the level at which the top of the Miocene deposits would be expected (fig. 6). Where the top of the Miocene deposits occurred at the anticipated level, there was assumed to be no channel. Where the top of the Miocene deposits was not penetrated at a depth of about 20 feet below where it would

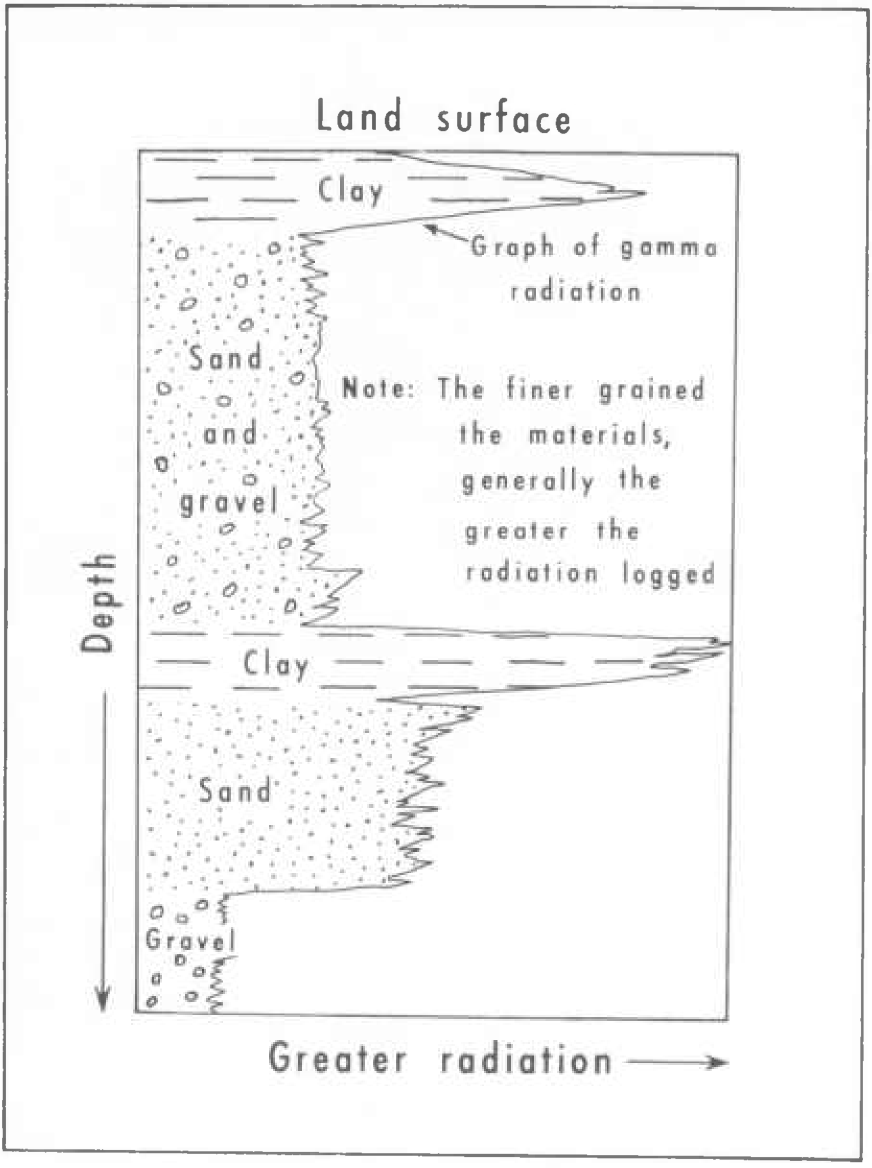


Figure 5. Diagram showing interpretation of gamma-ray log.

normally occur, the test hole was assumed to be in the channel. Thus it was possible to locate the channel by augering test holes along a line normal to it: first bracketing and then refining the lateral limits of the channel (fig. 7).

The mapped course of the channel was extended by augering test holes along successive lines. The additional lines of test holes were established normal to the postulated course of the channel and were spaced a half to 1 mile apart. Spacing the sequential lines of auger

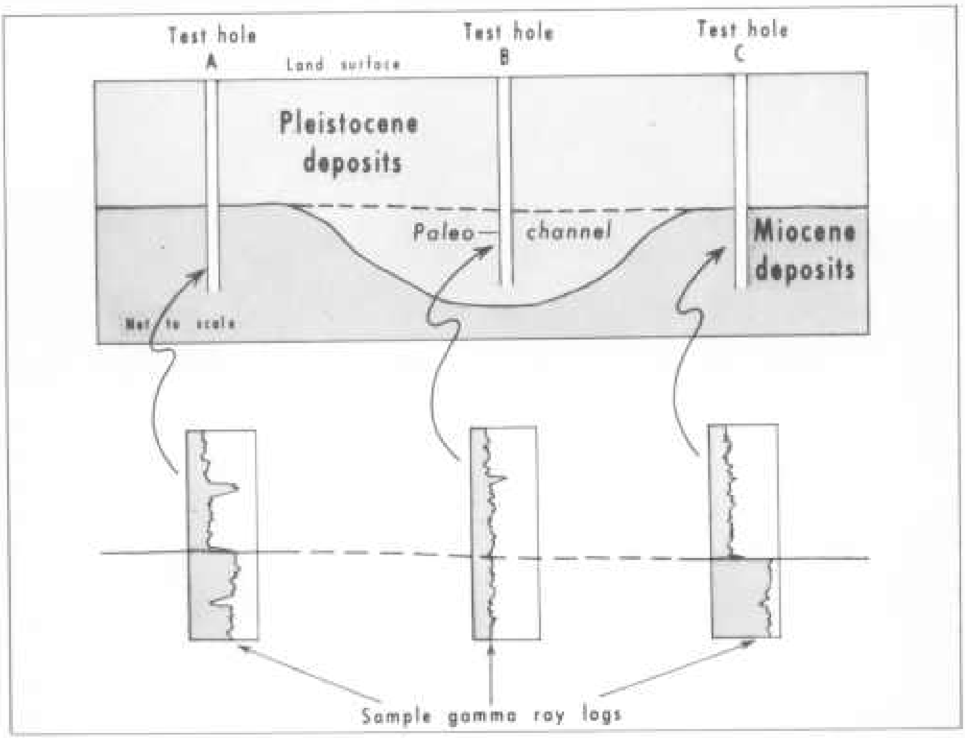


Figure 6. Diagrams showing basis of mapping technique using power auger and gamma-ray logging.

holes more than 1 mile apart was found to be inefficient because of the chance of intervening changes in course direction, channel width, and facies.

This technique proved to be relatively fast, flexible, and economical. In the western part of the area, where the channel maintained its width, its course was mapped at a rate of about 2/3 mile per day, or 6½ linear miles in 10 days. The cost of augering and gamma-logging was estimated to be less than a third that of conventional rotary drilling and the time, about half as much.

By conjunctive use of the power auger and gamma-ray logger it was possible to map the course and approximate lateral limits of the channel rapidly. Thus identified, it was then possible to explore the deep, central part of the channel with a minimum number of more expensive test holes drilled by conventional methods.

Detailed exploration was done northeast of Hebron along line A-A′ (fig. 8) to determine the depth and cross-sectional shape of the western part of the channel and to collect samples of materials deep in the channel. In addition to the test holes augered while mapping the course of the channel, three test holes were drilled through the bottom of the channel by rotary means. The construction of section A-A′ (fig. 11) utilized records from all those test holes.

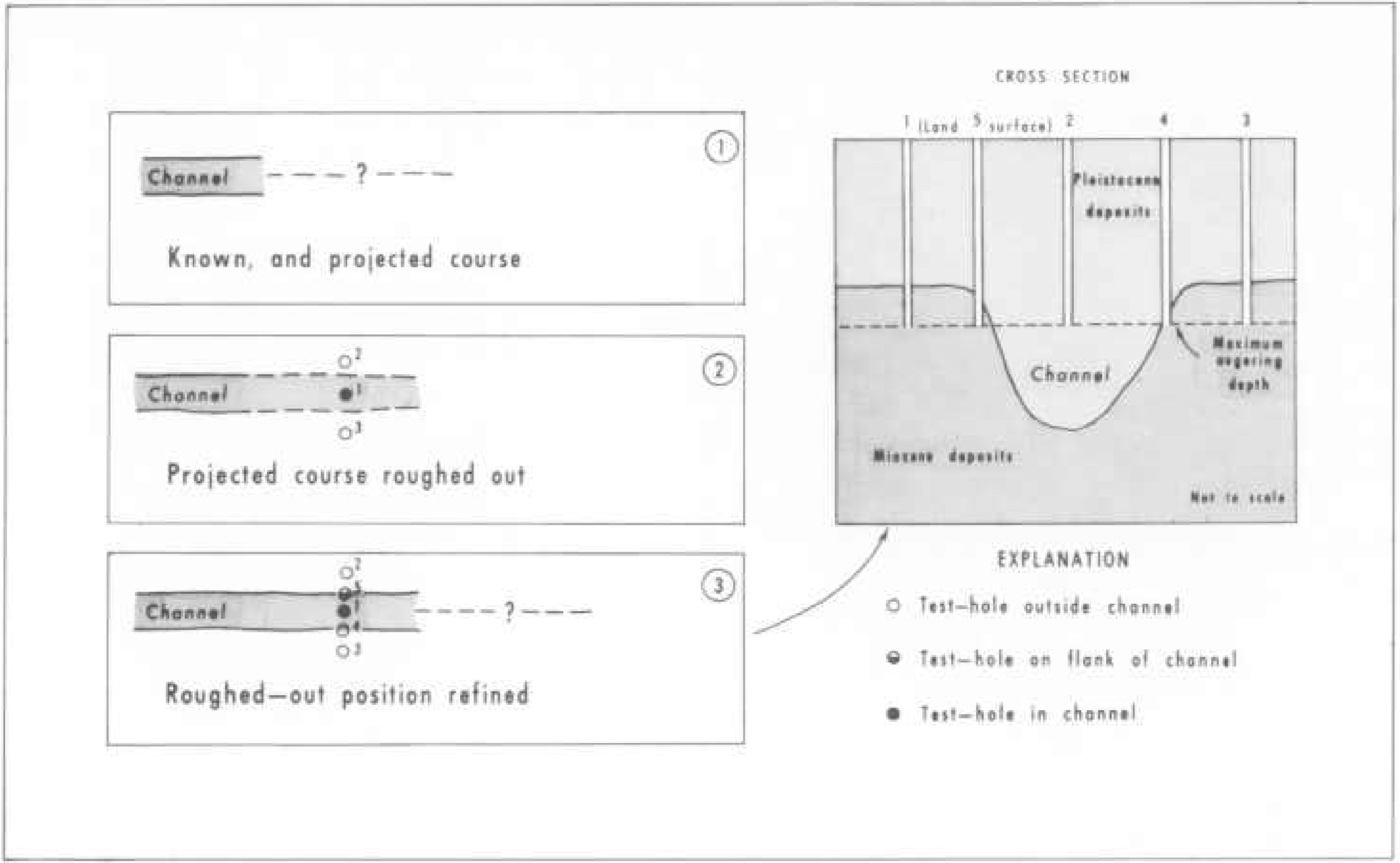


Figure 7. Diagrams showing application of mapping technique.

Other Methods Considered

Several other approaches to exploring the channel were considered. Some were discarded; others were held in abeyance.

Topographic Mapping of Subsidence Effects

The feasibility of mapping the channel course by determining topographic lows, which might occur along the course because of settling of the channel fill, was ruled out early in the field work when it became evident that the effects would have been masked by the overlying windblown deposits of fine sand and silt.

Such subsidence-related depressions in the land surface may have existed and some may have been repositories for swamp deposits and fine waterlaid sediments before being masked by eolian deposits. However, that possibility was not pursued during this study.

Stream Temperatures

Areas of relatively great ground-water contribution to streams can be mapped by measurement of stream temperatures, either directly or by airborne detection of infrared radiation. Assuming that ground-water discharge to a stream is greater where the stream cuts the paleochannel, temperature measurements along the stream should make it possible to pinpoint the greater ground-water discharge and thus locate the channel.

This method promises to be a useful tool for rapid qualitative and quantitative hydrology. During the present study, however, it could not be related directly to the geometry of the channel; hence, it was not used in mapping the channel.

Magnetometer

The most obvious and consistent difference between the Pleistocene and Miocene deposits is color. The color of the Pleistocene deposits characteristically has a reddish component generally lacking in the Miocene deposits. Assuming the color difference is due to difference in the content or chemical form of iron, the average magnetic susceptibility of the materials in the Pleistocene deposits should differ from that of the materials in the Miocene deposits. Furthermore, because the Pleistocene deposits thicken considerably in the vicinity of the channel, the magnetic susceptibility measured over the channel might then be different from that elsewhere in the area; possibly, the difference could be detected by a sufficiently sensitive instrument.

However, U. S. Geological Survey airborne magnetometer flights across the channel in 1968 at an elevation of about 400 feet and truck-mounted magnetometer runs across the channel in 1969 did not give positive results as far as channel-mapping was concerned (respective oral commun.: D. R. Mabey, 1969; and J. P. Owens, 1970).

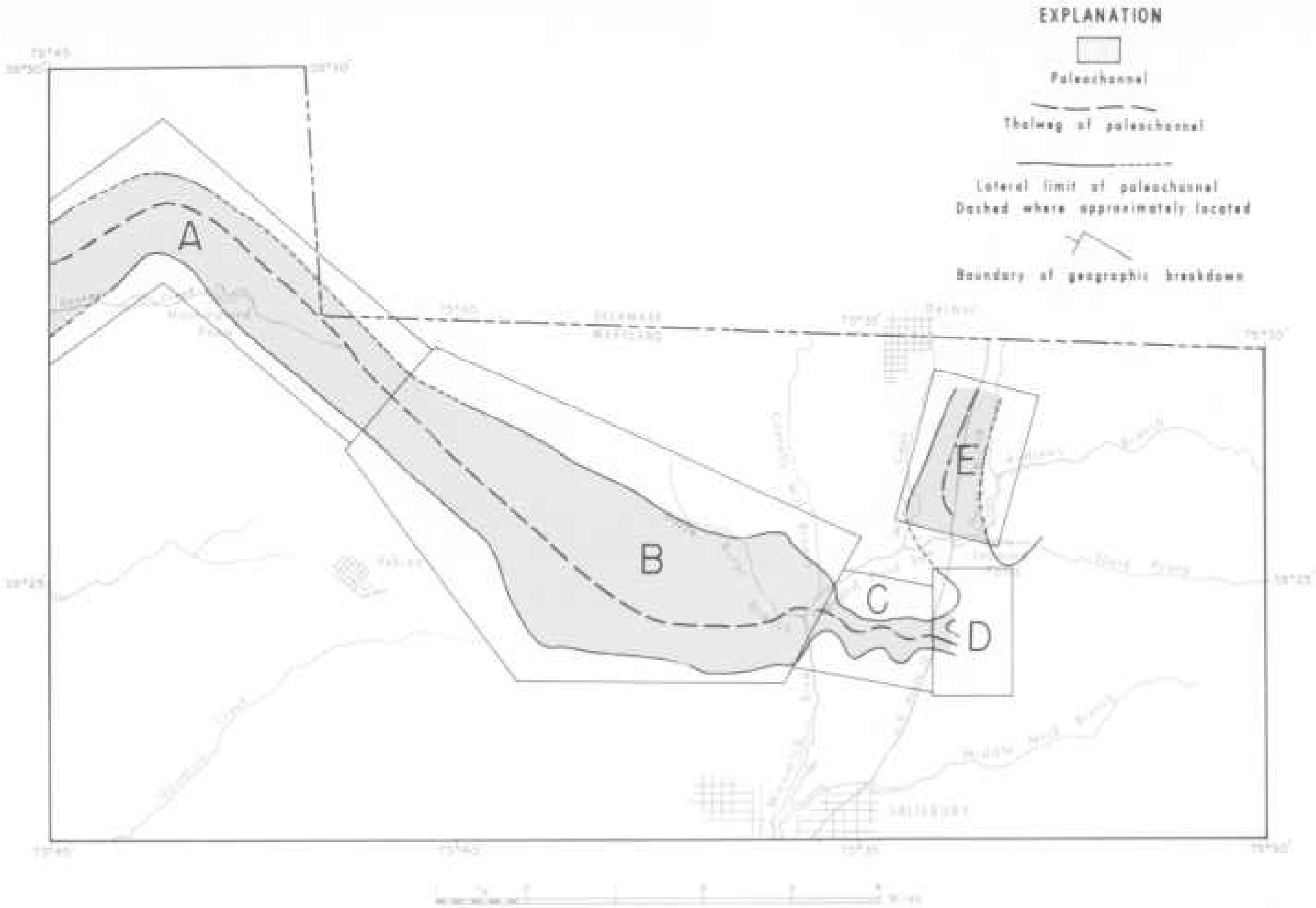


Figure 9. Map showing geographic breakdown of paleochannel for discussion purposes.

Seismic

Some thought was given to seismic methods. Possibly, reflected or refracted shock waves generated by a land-based source would indicate the position of the underlying Pleistocene-Miocene contact. There are suggestions, however, that the contrast in sound velocities in the materials concerned may be too small to permit discrimination.

Contrast in sound velocities permitting, sub-bottom profiling by acoustic means (boomer or sparker) along the Nanticoke and Wicomico Rivers might prove to be a rapid means of delineating channel crossings under those streams.

None of the seismic methods has been tested during the present study of the channel.

Electrical Resistivity

A land-based electrical-resisitivity profile across the channel in 1967 showed a definite anomaly over the channel. This method shows promise for delineating the channel (A. R. Zohdy, written commun. 1967), although interpretation might be difficult in those areas where the sea-level clay of Pleistocene age intervenes between the land surface and the Pleistocene-Miocene contact. In particular, it appears the electrical-resistivity method would be useful in locating a narrow channel and in determining the detailed cross-sectional shape of a channel.

CHANNEL GEOMETRY AND LITHOLOGY AS DETERMINED BY EXPLORATORY DRILLING

Wells and test holes pertinent to this report are described in table 2 (in Appendix) and are located on figure 8. Several, outside the study area, are located on figure 12.

The known extent and shape of the channel, and the relation of the channel to the base of the Pleistocene deposits, can be seen in figure 8. That illustration shows, by contours, the configuration of the base of the channel. For ease in discussion the channel has been subdivided into five geographic areas (A, B, C, D, and E) as shown in figure 9.

Channel Course

In all, about 10 linear miles of the channel were mapped by the auger and gamma-ray logging technique. A shallower and narrower channel segment 1½ miles long was also mapped north of the east end of the main channel.

The extent of the channel as determined by augering is shown in figure 8. The channel enters the area of figure 8 from the west near Mardela Springs and trends generally east-southeastward about 12 miles to the vicinity of U. S. Route 13, about 2 miles northeast of Salisbury. There the channel apparently shallows and becomes dis-

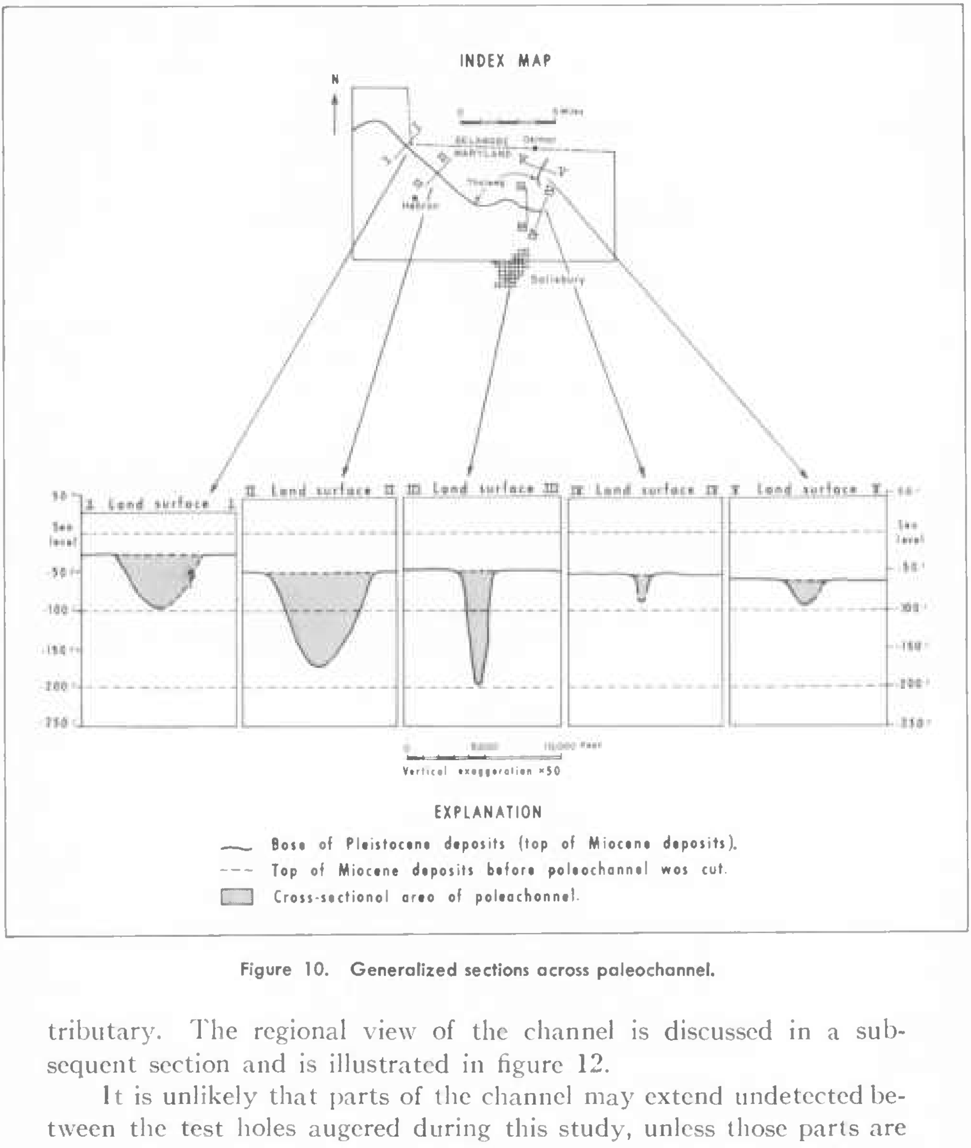


Figure 10. Generalized sections across paleochannel.

tributary. The regional view of the channel is discussed in a subsequent section and is illustrated in figure 12.

It is unlikely that parts of the channel may extend undetected between the test holes augered during this study, unless those parts are much narrower than the main channel where it has been mapped. An exception is in the vicinity of the southwest corner of Delaware, where information is scanty.

Cross-Sectional Shape and Gradient of Channel

The variation in the cross-sectional shape of the channel is shown by the five sections in figure 10. These sections indicate that the channel bottom deepens southeastward—with reference both to present land surface and to the former land surface into which the channel was cut—

from about 100 feet below sea level in area A to a maximum depth of about 200 feet below sea level in area C. The depth to which the channel was incised into the Miocene deposits ranges from about 60 feet in area A to 150 feet in area C.

In areas D and E the bottom is less well known but is believed to be shallow—probably 95 to 100 feet below sea level, (or incised only 40 or 50 feet into the Miocene deposits).

The width at the top of the channel ranges from about 3,500 to 9,000 feet in areas A and B to less than 1,000 feet in area C, as shown in figure 10. In reality the sections are much broader and shallower than they appear, but they have been compressed laterally by vertical exaggeration in order to emphasize their differences. Thus, it can be seen readily that in section III (fig. 10) the channel is relatively narrow and deep, while in section II it is relatively broad and shallow. Also, it is apparent that the cross-sectional channel area represented in section II is greater than the others and considerable greater than the areas in sections IV and V.

The bottom of the channel deepens southeastward between area A and area C (figs. 8, 9, 10). The gradient in area C is to the east, and the deepest known part of the channel system mapped in this report is in that area. The channel gradients in areas D and E are not known, but in parts of both the bottom is about 100 feet above that in area C.

Geologic Sections

The depth, cross-sectional shape, and character of materials in the middle of the wide northwestern part of the channel were determined by drilling test holes Wi-Be 41, 42, and 43 (geologic section A-A′ fig. 11). There the channel is wider and perhaps 30 feet shallower than to the east in area C (fig. 9). It is about ½ million square feet in cross-sectional area near section A-A′. It is about 1 mile wide at the top there and extends downward to about 170 feet below sea level or 120 feet below the top of the Miocene deposits, transecting the Manokin aquifer completely and bottoming on the St. Marys Formation. This part of the channel contains large amounts of saturated coarse sand and gravel similar to that in area C.

Section B-B′, in the narrow part of the channel (area C, fig. 9) also is shown in figure 11 for purposes of comparison. Section B-B′ was adapted from figure 16 in Boggess and Heidel (1968).

The Beaverdam Sand and red gravelly facies of the Salisbury aquifer are shown in sections A-A′ and B-B′ (fig. 11). The contact between the two facies is poorly defined in some places: at sites Be 36, 37, and 40 in section A-A′, for example, the two may even interfinger.

Also, the Manokin aquifer and lower aquiclude are not easily distinguished in the test holes along section A-A′. In those test holes the lower aquiclude is thin and is easily confused with thin clay beds in the underlying Manokin aquifer.

Lithology of Channel Fill

The channel fill represented in section A-A′ differs little from that in section B-B′ or elsewhere in the mapped part of the buried valley-channel system (see sections A-A′ and B-B′ fig. 11; and well logs in Appendix). The red gravelly facies, which fills the channel, is composed of interbedded sand (fine to very coarse) and sandy gravel and in some places cobbles. The materials are characteristically stained reddish-brown, orange, or tan and locally are cemented by limonite. The individual grains are generally subangular or subrounded.

Where the overlying Beaverdam Sand was penetrated in this study it was composed of fine to medium-grained sand, with some grit, pebbles, and white silt. Locally, the color was orange. In general, the materials were finer grained than those of the red gravelly facies.

Little or no lateral gradational change was noted in the Beaverdam Sand or red gravelly facies. However, there are some well-defined differences in parts of the Pleistocene deposits higher than the buried valley. For example, the sea-level clay near the top of the red gravelly facies is absent in most of the area but thickens locally to 20 or 30 feet. Also, a black or dark-gray, fine sandy, silty "muck" occurs at about 40 or 50 feet below sea level, generally north and east of Hebron, at the sites of test holes Wi-Bd 51, Be 40, and Ce 230; it may persist toward the west or southwest.

REGIONAL VIEW OF THE BURIED VALLEY-CHANNEL SYSTEM

What has been said thus far about the paleochannel has been stated with a fair degree of confidence. However, in relating the known extent of the paleochannel to a regional picture of the buried valley-channel system a greater degree of subjective judgment is introduced. With that in mind, the following statements are made regarding the buried valley-channel system.

The buried valley extends into Wicomico County from eastern Dorchester County, crossing the Nanticoke River near Vienna and perhaps several miles farther upstream (fig. 12). From Vienna it trends generally east-southeastward about 17 miles to the vicinity of U. S. Route 13, about 2 miles northeast of Salisbury. There it apparently shallows somewhat and becomes distributary. Valley width, and to some extent bottom gradient, change throughout the course that has been mapped.

Locations of parts of the buried valley shown in Dorchester County, west of the Nanticoke River, are adapted from Mack, Webb, and Gardner (fig. 26, 1972). The tie-in with the main part of the valley east of the Nanticoke River is tentative because of the scarcity of data. Nevertheless, consideration of valley width, orientation, and bottom gradients favors the overall configuation shown in figure 12.

In the vicinity of the southwest corner of Delaware the northeastern limit of the buried valley is not known, again owing to scarcity of data. Possibly the valley is joined there by an as yet unidentified tributary entering from the north in Delaware or by the northernmost branch of the buried valley shown west of the Nanticoke River, or by both.

One to 2 miles wide in its western and central parts, the valley narrows abruptly where it crosses the Wicomico River; from there eastward 1½ miles to U. S. Route 13 the valley is only a third to a half a mile wide and was incised more than a hundred feet deep—truly a channel.

North of Salisbury a narrow, sinuous closed depression (fig. 9) lies along the thalweg (lowest part) of the main channel. It is about 2½ miles long and about 20 feet deep—not unlike the dimensions of present-day similar closed depressions in the bottoms of the Potomac, Patuxent, and Choptank Rivers in the general area of the Chesapeake Bay and in similar estuaries elsewhere.

Existence of the closed depression north of Salisbury is contingent upon interpretation of well logs Wi-Ce 188 and 201, and Wi-Cf 150 (table 3 in Appendix). If the basal 20 to 30 feet of material designated as Pleistocene at each of those sites is assumed to be pre-Pleistocene in age, the closed depression disappears. However, even though the basal Pleistocene material in the westernmost and easternmost of the three wells is uncharacteristically fine, its color is characteristic of the Pleistocene material. Furthermore, at site Ce 188 (the middle well) those beds contain gravel, suggesting depositional changes more in keeping with Pleistocene than Miocene environmental conditions.

Paleochannel Gradients

The gradient of the base of the buried valley from the Nanticoke River to the Penn Central Railroad north of Salisbury averages 7.3 feet per mile, generally east-southeastward. The slope is steepest (22 feet per mile) in a 3-mile-long reach north of Hebron; otherwise, the slope is relatively gentle.

The segment of the buried valley from the southwest corner of Delaware to where it crosses the Penn Central Railroad north of Salisbury is about 7½ miles long. It includes the deepest and the widest known parts of the valley-channel system; also, it is better understood than are other parts of the system.

Along that 7½-mile segment the valley bottom, the surface into which the valley was cut, and the bedding planes of the Miocene deposits descend toward the east-southeast. The thalweg gradient averages about 12 feet per mile; the east-southeastward slopes of the beveled top of the Miocene deposits and the bedding in the Miocene deposits are respectively about 4 and 11 feet per mile.

The thalweg gradient and the Miocene bedding-plane slopes are about the same, therefore, but the eroded top of the Miocene deposits is more nearly horizontal. As a net result, although the channel is cut down through greater thicknesses of Miocene deposits toward the south-southeast, it is cut down to about the same or shallower stratigraphic depths (near the top of the St. Marys Formation) throughout the 7½ miles.

Knowledge of the gradient at the east end of the buried valley is incomplete. Based on available information the thalwegs in the individual channel branches are perhaps 100 feet higher than in the main channel immediately to the west. In at least one branch (that extending north-northeastward parallel to U. S. Route 13) the slope, as mapped, apparently is southward toward the main channel.

Configuration of the buried valley and relative gradients in the valley bottom and on the surface into which it was cut indicate the valley was carved by a stream that flowed generally southeastward and east-southeastward out of Dorchester County, across the Nanticoke River near Vienna and into Wicomico County—perhaps being joined by a tributary near the southwest corner of Delaware—and on to the present location of U. S. Route 13 northeast of Salisbury.

Eastern End of the Channel

The apparent branching at the east end of the channel and the gradient discontinuity (and perhaps reversal) between the main channel and its branches pose a problem that cannot be resolved decisively with the information now available. Several alternative solutions are suggested as follows:

1) Most likely the northern channel-segment (area E, fig. 9) is tributary to the main channel, and near the junction the channel deposits undergo a facies change from fluvial sand and gravel to estuarine silt and clay. If that is true, the coarse channel deposits (red gravelly facies) probably thin eastward under thickening deposits of estuarine or marine silt and clay and may interfinger with them.

2) The channel may become very narrow and continue east-southeastward, widening again where the materials into which it was cut were more easily eroded; or it may shallow somewhat, becoming distributary around former islands, and recombine to form a single channel somewhere down-valley.

3) Conversely, the channel may turn northward toward Delmar, and thence trend eastward in Delaware as part of a similar feature shown there by Sundstrom and Pickett (1970, fig. 19). However, the data available suggest the channel segment in area E (fig. 9) was cut by a southward-flowing tributary of the stream that cut the main Salisbury paleochannel.

Conditions near the east end of the channel must have differed significantly from those to the west, to account for the constriction of the valley in area C (fig. 9) and the abrupt change in channel configuration at the east end (area D, fig. 9). For one thing, the lower aquiclude (clay) is thicker there than to the west, and the underlying Manokin aquifer (sand) may be more resistant near the east end of the channel because of intercalated clay and silt. Also, the depositional environment in the channel eastward from U. S. Route 13 may have been estuarine, resulting in the facies change in the channel fill noted above. Furthermore, at one or more times the stream channel or a tributary may have been blocked—temporarily or permanently, locally or extensively—by slumping or by landslide, or conceivably by faulting, thereby damming and deflecting the stream.

Slumping

In most of its known course the stream cut down through readily eroded sandy deposits of Miocene age above the more resistant St. Marys Formation. Throughout the widest part of the valley the greater width may be accounted for in large part by undermining of the banks through ground-water sapping and lateral stream erosion that resulted in discontinuous widespread slumping of the overlying clay cap (the lower aquiclude). The clay cap, which the stream first encountered 1 or 2 miles east of Mardela Springs, thickens somewhat toward the southeast, and is as much as 20 or 30 feet thick near the east end of the channel.

Generally, the slumped clay and sand were carried off by the stream, but in some places they probably remained and were buried in the channel deposits. Although slumping may have been common, it was of doubtful importance as far as the course of the stream was concerned.

A greater significance of the slumping may be that the associated widening of the valley misleadingly suggests a greater volume of streamflow. In reality, at any one time the stream channel itself may have been no wider there than it was to the east in the constricted part of the valley. Stream velocities therefore probably were similar in the two parts of the channel, which would account for the general similarity in coarseness of deposits in those parts of the channel.

Landslides

Landslides may have been important in altering the course of the channel. The bedding planes in the Miocene deposits slope southeastward about 11 feet per mile. Where the clay deposits were saturated and their bedding planes well lubricated, conditions would be favorable for large masses of overlying material to slide laterally to the southeast, if lateral support on that side were removed. Under such conditions widespread landsliding has taken place along terrace scarps in the valleys of the Chehalis-Newaukum drainage system in west-central Lewis County, Washington, for example, since early in the Pleistocene Epoch (Weigle and Foxworthy, 1962, p. 7, 42-43).

Similar conditions probably existed in the northward-trending channel segment south of Delmar (fig. 12) before the newly cut channel was filled. Large masses of Miocene deposits may have slid laterally from the west wall of the channel (especially if the wall were steep), thereby partly blocking the channel. This may explain the apparent discontinuity between that channel segment and the main channel.

If the main stream originally flowed northward through the segment south of Delmar and were abruptly blocked, it could then have been deflected generally eastward across the present location of U. S. Route 13, cutting several relatively shallow distributary channels. The deep continuation of the original channel would then lie to the north, perhaps trending again east-southeastward near the Delaware State line. That possibility, though unlikely, may warrant further exploration at the north end of that segment of the channel.

GENERAL GEOHYDROLOGIC CONSIDERATIONS

Although this study is concerned primarily with exploratory methods and the geometry of the paleochannel, some thoughts about the local hydrology and implications for water availability are pertinent.

The mantle of Pleistocene material, general throughout the area, is a proven source of quantities of water more than sufficient to satisfy current domestic and most irrigation needs. Why, then, be concerned with the paleochannel as a source of water?

Drawdown available to wells in the thick Pleistocene deposits in the paleochannel is as much as twice that in the Pleistocene mantle outside the channel. Considering only the Pleistocene sand and gravel as a source of ground water, equivalent quantities of water can be obtained with fewer wells in the channel than would be required outside the channel.

The sand-and-gravel fill in the paleochannel is an outstanding aquifer. Its transmissivity (capacity to transmit what water is available to it) is high—as much as 400,000 gpd per foot (gallons per day per foot) (53,000 ft^2/day) near the junction of Little Burnt Branch and the Wicomico River, as determined by an aquifer test in 1967 (Mack and Thomas, part 1 of this bulletin). During that test a well in the channel deposits was pumped at 4,000 gpm (gallons per minute) for 30 days. Under conditions of long-term pumping at that rate, water would be obtained not only from the channel deposits but also from the adjacent Pleistocene deposits and underlying Manokin aquifer; in addition a substantial amount of water would be obtained by capturing streamflow and by reducing ground-water evapotranspiration through lowering the water table.

Elsewhere, along much of the main part of the channel between U.S. Route 13 and section A-A′ (figure 8), the transmissivity of the channel fill is probably 400,000 gpd per foot based on thicknesses and estimated permeabilities of the materials composing the fill. However, no substantial amounts of streamflow are available for capture except in the vicinity of the aquifer test referred to above. Hence, long-term sustainable yields from wells are likely to be less than at the site of the 4,000-gpm 30-day test, even though transmissivity values may be comparable.

Although the Manokin aquifer is a relatively unexploited additional source of ground water, high iron content may tend to limit development of water supplies from that source (Boggess and Heidel, 1968). The iron content of ground water from the Pleistocene deposits is generally less than that from the Manokin aquifer in the Salisbury area. Thus, the value of thick saturated Pleistocene deposits as a source of water is further enhanced.

Although ground water in the Pleistocene deposits—including the channel fill—is nominally under water-table conditions, locally it is subject to various degrees of partial confinement by the Walston Silt and the sea-level clay of Pleistocene age.

The Walston Silt is an extensive discontinuous sheet of interbedded clay, silt, and sand ranging from less than 1 to 20 feet in thickness. The grain size and effective hydraulic conductivity are variable. Where the Walston Silt is absent, or where it is most permeable, ground water in the Pleistocene deposits occurs under water-table conditions; where it is "tightest", the ground water is partly confined.

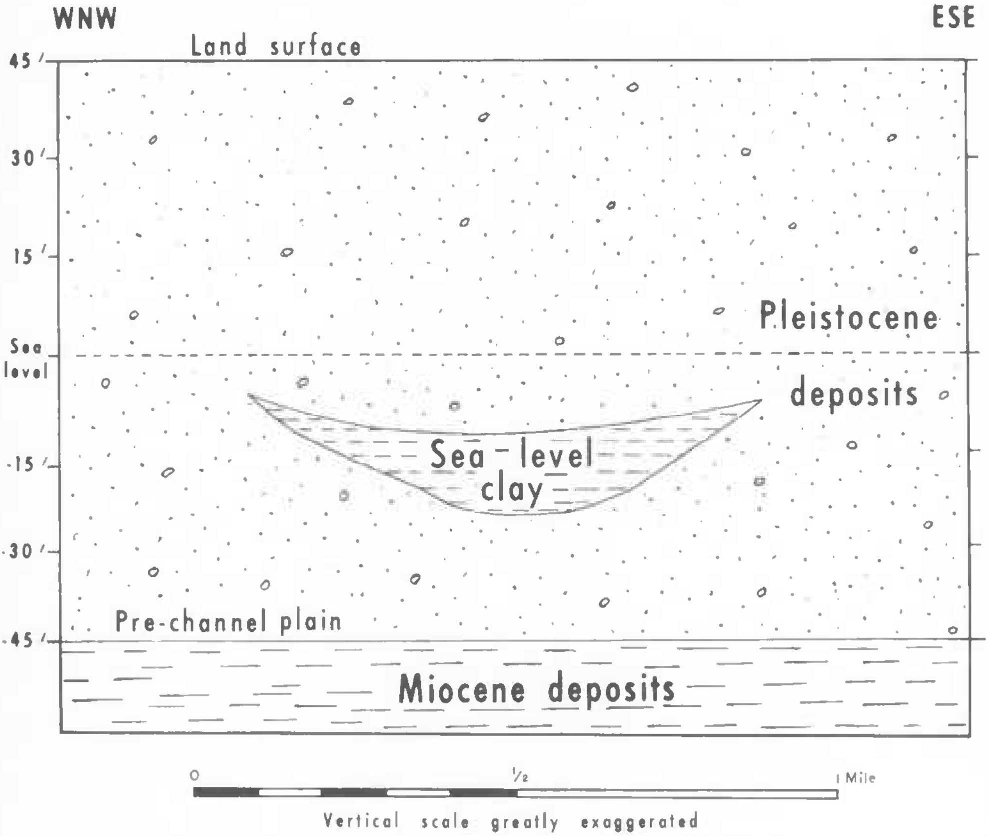


Figure 14. Idealized cross-section showing vertical relationships of sea-level clay of Pleistocene age.

The sea-level clay of Pleistocene age lies between 5 feet above and 25 feet below sea level. Its thickness and lateral extent are shown in figure 13 and its vertical relationships in figure 14.

This unit, a pink-brown and light-gray clay, occurs near the top of the red gravelly facies of Pleistocene age. It is found between 35 and 60 feet above the Miocene surface into which the paleochannel was cut. It may have originated as a quiet-water deposit in part of a drainage system near the top of the red gravelly facies—a drainage system lying 40 to 50 feet above the base of the Pleistocene deposits in general and postdating the formation of the Salisbury paleochannel. This part of a fossil drainage system near the top of the red gravelly facies is separated vertically, temporally, and genetically from the paleochannel.

The sea-level clay (where it was mapped) is lenticular and elongate, oriented northeast-southwest. It is at least 3½ miles long and may extend farther in both directions. It averages 10 or 15 feet in thickness and ranges in width from about ¼ to 1 mile. At several nodes (fig. 13) it thickens to 15 or 20 feet and widens to more than half a mile.

Where the sea-level clay is present it retards potential vertical movement of ground water in the Pleistocene materials, thereby introducing local artesian conditions in an area where water-table conditions prevail. This may mean that wells tapping the sand and gravel in the lower part of the Pleistocene deposits beneath the sea-level clay would yield less water on a short-term basis than would similar wells beyond the "umbrella" effect of that clay lens (fig. 14).

Water in the Manokin aquifer is confined. The head in the Manokin is believed to be higher than that in the Pleistocene deposits, at least in the eastern part of the area (see Manokin aquifer in table 1, and compare water levels in wells Ce 212 A and B, table 7; Mack and Thomas, part 1 of this bulletin).

To some extent, then, the deposits in and overlying the channel function as a ground-water drain and conduit, collecting water discharged by the Manokin aquifer in addition to ground-water recharge to the Pleistocene deposits themselves, and conducting it to streams such as the Wicomico River tributaries (fig. 9). If the water table in the channel fill were lowered by large-scale withdrawals of ground water, water would move from the Manokin aquifer and from the adjacent Pleistocene deposits into the channel deposits. In other words, the channel fill, the adjacent Pleistocene deposits, and the Manokin aquifer are an interconnected aquifer system; and the channel is the best place to exert drawdown on the system.

Recharge to the Pleistocene deposits in and above the channel is by direct infiltration of rainfall and snowmelt and by lateral movement of ground water from Pleistocene deposits adjacent to or in and above the channel. In addition water under higher head moves upward from the transected Manokin aquifer. Ground water in the Pleistocene deposits normally discharges to streams; but, if the water table in those deposits were to be lowered sufficiently, under conditions of good hydraulic continuity the streams probably would be induced to recharge the deposits and perhaps cease to flow—literally disappearing into the ground. The amount of water available in addition to that from direct recharge is the amount obtainable by capture from streams plus that from reduction in ground-water evapotranspiration because of lowering the water table.

In some parts of the channel, streams are not available to recharge the Pleistocene deposits, and the amount of ground water potentially available is therefore smaller.

Where the channel extends under the Nanticoke River, the channel deposits may be hydraulically connected with the river. If they are, there is a likelihood of local contamination of the deposits by salty or brackish water, provided ground-water withdrawal from those deposits near the river lowers the water table sufficiently to induce river water to move into them.

SUGGESTIONS FOR FUTURE STUDY

Some pertinent comments are offered below as guides to future investigation.

Although determining the unknown shape and extent of the channel at its east end might not disclose generally thick sections of saturated sand and gravel, the potential geologic significance is considerable.

In view of the apparently more complex and detailed shape of the channel east of U. S. Route 13, future mapping there might adventageously utilize resistivity profiling in combination with additional test drilling. Successful resistivity profiles along the lines shown in figure 12 would be of considerable value in locating narrow tributary or distributory channels quickly and precisely and in defining the degree of complexity of the local channel pattern. Simultaneously, test drilling could be employed to determine the channel depths and to determine if the channel deposits do, indeed, thin and continue east-southeastward under marine or estuarine silt and clay of Pleistocene age.

Elsewhere, in the vicinity of the southwest corner of Delaware, a small number of power-augered test holes would suffice to determine if the main channel there is joined by a tributary channel from the north or northwest.

In an area farther to the west conditions are favorable for testing the effectiveness of water-based acoustical profiling as a means of detecting buried valleys. The Salisbury paleochannel crosses the Nanticoke River near Vienna (fig. 12), and another branch of the channel may cross several miles upstream. If an attempt to detect the channel acoustically should prove successful there, the same method might be applied profitably elsewhere on the Delmarva Peninsula in lagoons, in navigable streams, and alongshore to aid in locating and mapping similar features.

Future hydrologic study presumably would determine, among other things, the transmissivity and storage values of the Manokin aquifer; stream discharges; permeability of silt on the stream bottoms; and the likelihood of local invasion of the channel deposits by brackish water from the Nanticoke River. Electric analog modeling might be of considerable help in predicting the movement of water in the system under various conditions of ground-water withdrawal.

Although the transmissivity of the channel aquifer has been determined at one place in the eastern part of the channel (Mack and

Thomas, part 1 of this bulletin), it is desirable to know the potential long-term sustainable ground-water yields available from the deposits elsewhere in the channel, not only where streamflow is present and potentially available to recharge the deposits (areas A and C, fig. 9) but also where streamflow is virtually absent (western two-thirds of area B, same figure). If a test well were installed in the channel about 2 miles east or northeast of Delmar and an aquifer test were conducted at the well during a period of no streamflow, an accurate value of the transmissivity of that part of the channel aquifer could be obtained, uncomplicated by the effects of recharge induced from streams.

Because the channel and its associated deposits are an important source of acceptable ground water, those deposits probably will be tapped heavily for ground water in the future. Therefore it is advisable to collect basic hydrologic information now, to be in a position to determine the effects of future withdrawals of ground water. That information should include water-level measurements in observation wells in Pleistocene and Miocene deposits in and near the paleochannel and complete chemical analyses of ground water from the same sources.

SUMMARY AND CONCLUSIONS

The objectives of this investigation were to further map the extent and shape of the channel where it might occur in the index area shown in figure 1, and simultaneously to test techniques for more rapid location and mapping of such features. The second objective was achieved. The first objective was achieved except for mapping the eastern part of the channel.

The paleochannel is a valley originally cut into an erosional surface at the top of the Miocene deposits and subsequently filled and covered by a blanket of Pleistocene deposits. Where the channel occurs, the Pleistocene-Miocene contact is much lower than it is outside the channel. Utilizing that information, the channel was located by mapping the contact topographically in the presumed channel direction by power-augering and gamma-logging through hollow drill-stem. Once the channel location was identified in that way, its deep central parts could be explored with a minimum number of test holes drilled by conventional methods. This technique proved to be rapid, inexpensive, and adaptable. Similar situations might warrant its consideration.

The paleochannel, or buried valley, enters Wicomico County from eastern Dorchester County, crossing the Nanticoke River near Vienna.

From there it trends generally east-southeastward more than 20 miles to the vicinity of U. S. Route 13, about 2 miles northeast of Salisbury. There it apparently shallows somewhat and becomes distributary.

The bottom gradient of the channel is downward toward the east-southeast. Comparison of that gradient with the slopes of the bedding planes in the Miocene deposits and the beveled top of the Miocene deposits suggests the channel was cut by a stream that flowed generally east-southeastward.

Down-valley from the southwest corner of Delaware the channel was cut down through the confining clay of the lower aquiclude, more or less completely transecting the sand and intercalated silt and clay that constitute the underlying Manokin aquifer, and bottomed near the top of the more resistant St. Marys Formation.

The buried valley is from 1 to 2 miles wide in its western and central parts, but narrows abruptly where it crosses the Wicomico River. In area C (fig. 9), where the feature was originally mapped (Hansen, 1966) it is only a third to a half a mile wide and is incised more than a hundred feet in the Miocene deposits.

The stream that cut the channel may have had similar velocities and volumes in areas B and C. The greater width in area B may have been produced by slumping caused by undermining of the materials of the Manokin aquifer in the valley walls by ground-water sapping and lateral stream erosion. Eastward, in area C, the constriction of the valley may be related to thickening of the Miocene clay cap and to greater resistance of the materials in the Manokin aquifer.

The Pleistocene deposits are the most prolific source of ground water of generally acceptable quality in the study area. The hydrologic significance of the channel lies in the fact that is constitutes a downward thickening of the blanket of Pleistocene materials.

Large amounts of available ground water are stored in the channel deposits. More important, because of their greater thickness, the saturated Pleistocene deposits of sand and gravel in the middle of the channel offer approximately twice the drawdown available to wells outside the channel. Because of that, individual wells drilled in the channel can produce much more water from the Pleistocene deposits than wells drilled outside the channel can. Also, owing to the greater available drawdown, the channel and its deposits could function as a drain and induce water to move from the adjoining Pleistocene materials and from the underlying Manokin aquifer.

Where streams traverse the channel deposits, the potential ground-water yield from the deposits may be greatly augmented by the diversion of streamflow into them. This factor is of considerable importance where the North Prong of the Wicomico River and Little Burnt Branch traverse the channel (Boggess and Heidel, 1968; Mack and Thomas, part 1 of this bulletin). It is probably of considerable importance also near the southwest corner of Delaware, where the channel passes beneath Baron Creek and Mockingbird Pond (although somewhat less important because the streamflow is smaller there).

At the east end of the channel the apparent branching and the gradient discontinuity or reversal cannot be resolved decisively without further exploration. East of U. S. Route 13 the course of the channel is not known, although it may:

1) Continue generally east-southeastward, under estuarine silt and clay of Pleistocene age that begin near U. S. Route 13 and thicken eastward. If that is true, the coarse channel deposits probably thin eastward beneath the estuarine sediments and interfinger with them.

2) Become very narrow, continue east-southeastward, and widen again where the materials into which it was cut were more easily eroded.

3) Shallow somewhat, becoming distributary around former islands, and recombine to form a single channel down-valley.

4) Trend northward toward Delmar, and thence eastward in Delaware.

The actual course taken by the channel east of U. S. Route 13 was determined by the environmental factors dominant then. Those factors may have included a change to an estuarine depositional environment in the channel east of U. S. Route 13, caused by a general rise in sea level; this suggests possibility (1) above. Alternatively, there may have been a general increase eastward in resistance to erosion, which suggests possibility (2) or (3). Or, conceivably, the channel originally trended northward toward Delmar and thence eastward; landsliding may have blocked the northward-trending segment of the channel and deflected the streamflow eastward, which would suggest a qualified possibility (4).

The answer to this puzzle obviously requires exploratory work, the nature of which has been outlined earlier in the report.

References

Boggess, D. H., and Heidel, S. G., 1968, Water resources of the Salisbury area, Maryland: Maryland Geol. Survey Rept. Inv. 3, 69 p.

Hack J. T., 1957, Submerged river system of Chesapeake Bay: Bull. Geol. Soc. America, v. 68, no. 7, p. 817-830.

Hansen, H. J., III, 1966, Pleistocene stratigraphy of the Salisbury area, Maryland and its relationship to the lower Eastern Shore: a subsurface approach: Maryland Geol. Survey Rept. Inv. 2, 56 p.

Harrison, W., Malloy, R. J., Rusnak, G. A., Terasmae, J., 1965, Possible late Pleistocene uplift Chesapeake Bay entrance: Jour. Geology, v. 73, p. 201-229.

Heidel, S. G., 1965, Dissolved oxygen and iron in shallow wells at Salisbury, Md.: Jour. Amer. Water Works Assoc. Vol. 57, No. 2, p. 239-244.

Heidel, S. G., and Otton E. G., 1963, Geochemistry of water in the Salisbury, Maryland well field: U. S. Geol. Survey open-file rept., 48 p.

Mack, F. K., Wenn, W. E., and Gardner, R. A., 1971, Water resources of Dorchester and Talbot Counties, Maryland, with special emphasis on the ground water potential of the Cambridge and Easton areas: Maryland Geol. Survey Rept. Inv. 17, 107 p.

Murphy, J. J., 1957, Salinity studies in estuaries of the Eastern Shore *in* The water resources of Caroline, Dorchester, and Talbot Counties: Maryland Dept. of Geology, Mines and Water Resources[1] Bull. 18, p. 426-446.

Rasmussen, W. C., and Andreasen, G. E., 1959, Hydrologic budget of the Beaverdam Creek basin, Maryland: U. S. Geol. Survey Water Supply Paper 1472, 106 p.

Rasmussen, W. C., and Slaughter, T. H., 1955, The ground water resources *in* The water resources of Somerset, Wicomico, and Worcester Counties: Maryland Dept. of Geology, Mines and Water Resources[1] Bull. 16, 533 p.

Ryan, J. D., 1953, The sediments of Chesapeake Bay: Maryland Dept. Geology, Mines and Water Resources[1] Bull. 12, 120 p.

Sundstrom, R. W., and Pickett, T. E., 1970, The availability of ground water in western Sussex County, Delaware: Water Resources Center, Univ. of Delaware 118 p.

Weigle, J. M., and Foxworthy, B. L., 1962, Geology and ground water resources of west central Lewis County, Washington: Washington Div. Water Resources Water Supply Bull. 17, 248 p.

[1]The name of this agency was changed to the Maryland Geological Survey in June 1964.

Appendix

Table 2.—Descriptions of wells and test holes referred to in this report.

Altitude of land surface: Datum is mean sea level. Altitudes expressed in whole feet were interpolated from topographic maps. Those in feet and tenths of feet were measured.
Depth of well: Depths expressed feet and tenths were measured; those expressed in whole feet were reported. Depths are below land-surface datum.
Principal water-bearing unit: For description of unit, see table 1. Water level: Water levels were reported, except those followed by "a" which were measured.

Well number Wi-	State permit number	Owner or name	Driller	Date completed	Altitude of land surface (feet)	Method of construction	Depth of well (feet)	Diameter of well (inches)	Depth of bottom of casing or top of screen (feet below land surface)	Total screen length (feet)	Principle waterbearing unit	Water level: Feet below land surface	Water level: Date	Use	Type of pump	Gallons per minute (gpm)	Yield: Duration of test (hrs)	Yield: Drawdown (feet)	Yield: Date	Specific capacity (gpm/foot of drawdown)	Remarks	Well number Wi-
Bc 47	4[illegible]206	Tri-County Medical Association	N. M. Shannahan	3/30/61	30	Dr	290	2-1½	277	10	M	11	3/30/61	N	-	18	4	-	-	-		Bc 47
Bc 52	-	____ Everman	E. R. Kauffman	7/-/64	10	Dr(?)	136	13	28	60	Sa(?), M	9	7/29/64	Ir	-	931	-	60	-	15.5	Screened 12-16, 28-32, 44-84, 88-92, 96-100, 132-136.	Bc 52
Bc 53	Wi690068	W. E. Walmsley	G. B. Kelley	1969-70	28	Dr	300	2	280	10	M	17	-	D	-	15	2	8	-	1.9		Bc 53
Bc 54	Wi690048	Roland Bennett	do.	11/12/68	26	Dr	310	2	283	20	M	12	11/12/68	D	-	-	-	10	-	-		Bc 54
Bc 55	Wi690096	Robert Parson	do.	2/24/69	8	Dr	320	2	300	20	M	6	2/24/69	D	-	10	-	19	-	0.5		Bc 55
Bc 56	Wi690102	Russell Miller	do.	6/17/69	22	Dr	300	2	280	16	M	10	6/17/69	D	-	20	2	10	-	2.0		Bc 56
Bd 11	-	Mardela Springs High School	Shannahan Artesian Well Co.	1945	25	J	305	6-4½	-	-	M	8	11/-/45	-	-	-	-	-	-	-	L-16 (chemical analysis in same source).	Bd 11
Bd 45	-	-	____ Baldwin	1953	25	J	231	6-4	-	-	M	-	-	T	N	-	-	-	-	-	L-16.	Bd 45
Bd 46	-	M. V. Ellis	S. V. Shannahan	10/15/59	32	J	319	4-2½	308	9	M	23	10/15/59	D,C	J	40	6	41	10/15/59	1.0		Bd 46
Bd 50	-	Wicomico County Board of Education	do.	11/3/58	25	J	310	4	298	11	M	28	11/-/58	Ins	-	100	8	34	11/-/58	2.9		Bd 50
Bd 51	-	Wicomico County	U.S. Geological Survey	11/19/68	38	A	133	4½	-	-	Sa	-	-	T	N	-	-	-	-	-	L, Lg.	Bd 51
Bd 52	-	do.	do.	11/20/68	32	A	133	4½	-	-	Sa	-	-	T	N	-	-	-	-	-	L, Lg.	Bd 52
Bd 53	-	do.	do.	11/20/68	39	A	78	4½	-	-	Sa	-	-	T	N	-	-	-	-	-	Lg.	Bd 53
Bd 54	-	do.	do.	10/3/69	38	A	155	4½	-	-	Sa	-	-	T	N	-	-	-	-	-	Lg.	Bd 54
Bd 55	-	do.	do.	10/10/69	42	A	117	4½	-	-	Sa	-	-	T	N	-	-	-	-	-	Lg.	Bd 55
Bd 56	-	do.	do.	10/10/69	30	A	102	4½	-	-	Sa	-	-	T	N	-	-	-	-	-	Lg.	Bd 56
Bd 57	-	do.	do.	10/13/69	30	A	132	4½	-	-	Sa	-	-	T	N	-	-	-	-	-	Lg.	Bd 57
Bd 58	-	do.	do.	10/13/69	34	A	133	4½	-	-	Sa	-	-	T	N	-	-	-	-	-	Lg.	Bd 58

Method of construction
- A Power augered
- Cd Core drilled
- Dc Cable tool
- Dr Hydraulic rotary
- J Jetted

Principal water-bearing unit
- Sa Salisbury aquifer
- M Miocene deposits, undifferentiated
- Mk Manokin aquifer

Water level
- a Measured

Use
- C Commercial
- D Domestic
- Ind Industrial
- Ins Institutional
- Ir Irrigation
- N Not used
- O Observation
- S Stock
- T Exploratory test hole

Type of pump
- J Jet
- N None
- P Piston
- Sb Submersible
- Sn Suction
- T Turbine

Remarks
- A Chemical analysis in table 4
- L Descriptive log in table 3
- L-2 Descriptive log in Md. Geol. Survey Rept. of Inv. No. 2
- L-16 Descriptive log in Md. Dept. of Geology, Mines and Water Resources Bull. 16
- Lg Geophysical log available

Table 2.--Descriptions of wells and test holes referred to in this report--Continued.

Well number Wi-	State permit number	Owner or name	Driller	Date completed	Altitude of land surface (feet)	Method of construction	Depth of well (feet)	Diameter of well (inches)	Depth of bottom of casing or top of screen (feet below land surface)	Total screen length (feet)	Principle waterbearing unit	Water level: Feet below land surface	Water level: Date	Use	Type of pump	Gallons per minute (gpm)	Yield: Duration of test (hrs)	Yield: Drawdown (feet)	Yield: Date	Specific capacity (gpm/foot of drawdown)	Remarks	Well number Wi-
Bd 59	-	Wicomico County	U.S. Geological Survey	10/14/69	31	A	132	4½	-	-	Sa	-	-	T	N	-	-	-	-	-	Lg.	Bd 59
Bd 60	-	do.	do.	10/15/69	30	A	122	4½	-	-	Sa	-	-	T	N	-	-	-	-	-	Lg.	Bd 60
Bd 61	Wi700005	Percy Lewis	M. P. Brittingham	1/24/70	25	J	307	2	248	0	M	14	1/24/70	D	-	20	-	72	-	0.3		Bd 61
Bd 62	Wi690044	Charles Wright, Jr.	G. B. Kelley	10/8/68	40	Dr	330	4-2	295	25	M	18	10/8/68	N	-	-	-	5	-	-	Report water too irony for domestic use.	Bd 62
Bd 63	Wi690043	Charles Wright III	do.	10/10/68	33	Dr	320	4-2	285	20	M	18	10/10/68	D	-	25	-	-	-	-		Bd 63
Be 20	-	-	R. B. White	1950	65	J	120.0m	-	-	-	Sa	23.4m	7/27/50	T	N	-	-	-	-	-	L-16.	Be 20
Be 26	37517	H. M. Hearne	R. F. Maher	4/21/60	49	Dr	105.4	22	0	53	Sa	8.8m	8/14/63	Ir	-	1020	4	28	4/21/60	36.4	Alternately cased and screened.	Be 26
Be 32	-	Wicomico County	U.S. Geological Survey	11/8/68	45	A	128	4½	-	-	Sa	-	-	T	N	-	-	-	-	-	Lg.	Be 32
Be 33	-	do.	do.	11/9/68	48	A	128	4½	-	-	Sa	-	-	T	N	-	-	-	-	-	Lg.	Be 33
Be 34	-	do.	do.	11/9/68	48	A	128	4½	-	-	Sa	-	-	T	N	-	-	-	-	-	Lg.	Be 34
Be 35	-	do.	do.	11/11/68	48	A	133	4½	-	-	Sa	-	-	T	N	-	-	-	-	-	Lg.	Be 35
Be 36	-	do.	do.	11/14/68	50	A	133	4½	-	-	Sa	-	-	T	N	-	-	-	-	-	L, Lg.	Be 36
Be 37	-	do.	do.	11/14/68	49	A	133	4½	-	-	Sa	-	-	T	N	-	-	-	-	-	L, Lg.	Be 37
Be 38	-	do.	do.	11/15/68	44	A	153	4½	-	-	Sa	-	-	T	N	-	-	-	-	-	Lg.	Be 38
Be 39	-	do.	do.	11/18/68	44	A	128	4½	-	-	Sa	-	-	T	N	-	-	-	-	-		Be 39
Be 40	-	do.	do.	11/19/68	44	A	113	4½	-	-	Sa	-	-	T	N	-	-	-	-	-	L, Lg.	Be 40
Be 41	-	do.	do.	5/14/69	55	Dr	260	6	-	-	Sa,Mk	-	-	T	N	-	-	-	-	-	L, Lg.	Be 41
Be 42	-	do.	do.	5/15/69	48	Dr	260	6	-	-	Sa	-	-	T	N	-	-	-	-	-	L, Lg.	Be 42
Be 43	-	do.	do.	5/16/69	44	Dr	200	6	-	-	Sa	-	-	T	N	-	-	-	-	-	L, Lg.	Be 43
Be 44	-	do.	do.	10/3/69	43	A	122	4½	-	-	Sa	-	-	T	N	-	-	-	-	-	Lg.	Be 44

Method of construction

A Power augered
Cd Core drilled
Dc Cable tool
Dr Hydraulic rotary
J Jetted

Principal water-bearing unit

Sa Salisbury aquifer
M Miocene deposits, undifferentiated
Mk Manokin aquifer

Water level

m Measured

Use

C Commercial
D Domestic
Ind Industrial
Ins Institutional
Ir Irrigation
N Not used
O Observation
S Stock
T Exploratory test hole

Type of pump

J Jet
N None
P Piston
Sb Submersible
Sn Suction
T Turbine

Remarks

A Chemical analysis in table 4
L Descriptive log in table 3
L-2 Descriptive log in Md. Geol. Survey Rept. of Inv. No. 2
L-16 Descriptive log in Md. Dept. of Geology, Mines and Water Resources Bull. 16
Lg Geophysical log available

Table 2.--Descriptions of wells and test holes referred to in this report--Continued.

Well number	State permit number	Owner or name	Driller	Date completed	Altitude of land surface (feet)	Method of construction	Depth of well (feet)	Diameter of well (inches)	Depth of bottom of casing or top of screen (feet below land surface)	Total screen length (feet)	Principle waterbearing unit	Water level: Feet below land surface	Water level: Date	Use	Type of pump	Yield: Gallons per minute (gpm)	Yield: Duration of test (hrs)	Yield: Drawdown (feet)	Yield: Date	Specific capacity (gpm/foot of drawdown)	Remarks	Well number
Be 45	-	J. W. Aydelotte, Jr.	U.S. Geological Survey	10/17/69	20	A	117	4½	-	-	Sa	-	-	T	N	-	-	-	-	-	Lg.	Be 45
Be 46	-	Wicomico County	do.	10/21/69	50	A	95	1¼	91	3½	Sa	10.0^{m}	10/22/69	T	N	-	-	-	-	-	L, Lg, A, Temp. 17°C. Augered 132 feet deep.	Be 46
Be 47	-	do.	do.	10/22/69	50	A	36	1¼	32	3½	Sa	9.7^{m}	10/22/69	T	N	-	-	-	-	-	Augered 39 feet deep, 17 feet south of Be 46. Lg. A, Temp. 18°C.	Be 47
Be 48	-	do.	do.	10/9/69	44	A	127	4½	-	-	Sa	-	-	T	N	-	-	-	-		Lg.	Be 48
Be 49	W165W58	Howard Nichols	M. P. Brittingham	11/4/64	43	J	102	2	69	14	Sa	10	11/4/64	D	J	40	3	13	11/4/64	3.1		Be 49
Be 50	W168W82	H. M. Hearne	Wilson States	2/26/68	50	Dr	96	17	28	-	Sa	5	2/26/68	Ir	-	1190	2	22	1968	54.1	Lg. Concrete, alternate screen and casing.	Be 50
Bf 8	-	Pennsylvania Railroad	-	1885	50	Dc(?)	402	-	-	-	-	-	-	-	N	-	-	-	-	-	L-16. Exact location not known.	Bf 8
Bf 13	-	-	R. B. White	1950	40	J	105.0^{m}	-	-	-	Sa	-	-	T	N	-	-	-	-	-	L-16.	Bf 13
Bf 37	35389	Morris Ward	E. F. Schultz	1959	47	J	110	2	100	10	Sa	18	7/21/59	D	-	60	3	12	7/21/59	5.0	L-2.	Bf 37
Bf 44	W165W67	Walter Shockley, Jr.	M. P. Brittingham	1965	48	J	99	2	86	13	Sa	16.9^{m}	1/26/65	S	J	20	18	12	1/15/65	1.7	Jetted 120 feet deep.	Bf 44
Bf 45	W165W71	W. P. Chew	do.	1965	55	J	104	2	96	8	Sa	9.2^{m}	1/29/65	D,S	P	28	18	14	1/28/65	2.0	L-2. Jetted 144 feet deep.	Bf 45
Bf 46	W165W68	W. S. Murrey, Jr.	do.	1965	50	J	100	2	90	10	Sa	16.9^{m}	1/12/65	D	-	35	5	12	1/12/65	2.9	Jetted 137 feet deep.	Bf 46
Bf 47	W168W93	Lulu Cline	Ideal Well Drillers	1968	42	Dr	125	2	120	5	Sa	18	2/15/68	D	-	30	3	6	2/15/68	5.0	Lg. Drilled 150 feet deep.	Bf 47
Bf 48	-	Wicomico County	U.S. Geological Survey	5/17/68	47	A	112	4½	-	-	Sa	-	-	T	N	-	-	-	-	-	Lg.	Bf 48
Bf 49	-	do.	do.	5/20/68	46	A	122	4½	-	-	Sa	-	-	T	N	-	-	-	-	-	Lg.	Bf 49
Bf 50	-	do.	do.	5/20/68	45	A	122	4½	-	-	Sa	-	-	T	N	-	-	-	-	-	L, Lg.	Bf 50
Bf 51	-	do.	do.	5/22/68	43	A	122	4½	-	-	Sa	-	-	T	N	-	-	-	-	-	Lg.	Bf 51
Bf 52	-	do.	do.	11/21/68	45	A	138	4½	-	-	Sa	-	-	T	N	-	-	-	-	-	Lg.	Bf 52
Bf 53	-	do.	do.	11/21/68	45	A	128	4½	-	-	Sa	-	-	T	N	-	-	-	-	-	Lg.	Bf 53
Bf 54	-	do.	do.	11/22/68	48	A	133	4½	-	-	Sa	-	-	T	N	-	-	-	-	-	Lg.	Bf 54
Bf 55	-	do.	do.	11/22/68	46	A	143	4½	-	-	Sa	-	-	T	N	-	-	-	-	-	Lg.	Bf 55

Method of construction
- A Power augered
- Cd Core drilled
- Dc Cable tool
- Dr Hydraulic rotary
- J Jetted

Principal water-bearing unit
- Sa Salisbury aquifer
- M Miocene deposits, undifferentiated
- Mk Manokin aquifer

Water level
- m Measured

Use
- C Commercial
- D Domestic
- Ind Industrial
- Ins Institutional
- Ir Irrigation
- N Not used
- O Observation
- S Stock
- T Exploratory test hole

Type of pump
- J Jet
- N None
- P Piston
- Sb Submersible
- Sn Suction
- T Turbine

Remarks
- A Chemical analysis in table 4
- L Descriptive log in table 3
- L-2 Descriptive log in Md. Geol. Survey Rept. of Inv. No. 2
- L-16 Descriptive log in Md. Dept. of Geology, Mines and Water Resources Bull. 16
- Lg Geophysical log available

Table 2.--Descriptions of wells and test holes referred to in this report--Continued.

Well number Wi-	State permit number	Owner or name	Driller	Date completed	Altitude of land surface (feet)	Method of construction	Depth of well (feet)	Diameter of well (inches)	Depth of bottom of casing or top of screen (feet below land surface)	Total screen length (feet)	Principle waterbearing unit	Water level: Feet below land surface	Water level: Date	Use	Type of pump	Yield: Gallons per minute (gpm)	Yield: Duration of test (hrs)	Yield: Drawdown (feet)	Yield: Date	Specific capacity (gpm/foot of drawdown)	Remarks	Well number Wi-
Bf 56	-	Wicomico County	U.S. Geological Survey	11/23/68	50	A	152	4½	-	-	Sa	-	-	T	N	-	-	-	-	-	Lg.	Bf 56
Bf 57	-	Donald Wilbur	do.	10/6/69	30	A	107	4½	-	-	Sa	-	-	T	N	-	-	-	-	-	L, Lg.	Bf 57
Bf 58	-	-	do.	10/6/69	42	A	117	4½	-	-	Sa	-	-	T	N	-	-	-	-	-	Lg.	Bf 58
Bf 59	-	Wicomico County	do.	10/7/69	49	A	127	4½	-	-	Sa	-	-	T	N	-	-	-	-	-	Lg.	Bf 59
Bf 60	-	do.	do.	10/7/69	45	A	132	4½	-	-	Sa	-	-	T	N	-	-	-	-	-	Lg.	Bf 60
Bf 61	-	do.	do.	10/9/69	45	A	152	4½	-	-	Sa	-	-	T	N	-	-	-	-	-	Lg.	Bf 61
Bf 62	-	do.	do.	10/20/69	47	A	117	4½	-	-	Sa	-	-	T	N	-	-	-	-	-	Lg.	Bf 62
Bf 63	Wi6-W10	Earl Banks	C. J. Bundick	1967	45	Dr	105	2	100	5	Sa	-	-	D	-	35	2	-	1967	-		Bf 63
Cd 33	6929	-	R. B. White	1950	40	J	210	1½	-	-	M	2.6m	7/19/50	T	N	-	-	-	-	-	L-16.	Cd 33
Cd 46	39351	Rolandhurst Nurseries	E. R. Kauffman	1962	24	Dr	350	2	290	60	M	18	11/8/62	D	Su	7	8	7	11/8/62	1.0	Drilled 360 feet deep. Report yield limited.	Cd 46
Cd 55	38703	Andrews Nursery	do.	1960	45	Dr	103.9	4	55	-	Sa,Mk	5.8m	9/20/63	Ir	-	30	8	6	5/2/60	5.0	Screen 55-75, 95-105 feet. Drilled 120 feet deep.	Cd 55
Cd 56	38563 38702	do.	do.	1960	45	Dr	158	17	-	-	Sa,Mk	6.4m	9/20/63	Ir	T	1280	12	43½	5/13/60	29.4		Cd 56
Cd 58	38704	Bounds-Phillips, Inc.	do.	1960	40	Dr	93.7	4	75	20	Sa,Mk	8	4/28/60	Ir	-	50	2	12	4/28/60	4.2		Cd 58
Ce 14	-	City of Salisbury	Kelley Well Co.	1925	25	Dc(?)	146	10-8-6	62 101	8 6	Sa Mk	15.1 4.0	1925 1925	T	N	18 5	-	-	1925 1925	-	L-16. Chemical analysis also in Bull. Screened at two successive levels, and tested.	Ce 14
Ce 15	-	do.	do.	1925	29	Dr	73	10-8	-	10	Sa	19	1925	T	N	-	-	-	-	-	L-16. Report temperature 57°F (1925).	Ce 15
Ce 102	-	Mardel Byproducts Corp.	M. A. Pentz	1951	42	J	80	6	-	-	-	10	5/2/51	Ind	T	-	-	-	-	-	L-16.	Ce 102
Ce 116	41486	1. H. Guy	E. R. Kauffman	1961	36	Dr	84	22	4	40	Sa	6.5m	8/23/63	Ir	Su	943	4	23	1/12/61	41.0	L-2. Well alternately cased and screened.	Ce 116
Ce 118	28095	Maryland National Guard Armory	M. M. Shannahan	1957	25	Dr	68	6	57	11	Sa	16.7 17.5m	8/8/57 9/11/63	Ins	Sb	60	8	12.3	8/8/57	4.9	L-2. Chemical analysis in Md. Geol. Survey Rept. of Inv. 3 Temperature 57°F. 3/24/64.	Ce 118
Ce 145	-	Wicomico County	U.S. Geological Survey	1963	36	A-Cd	92	-	-	-	Sa	18	11/7/63	T	N	-	-	-	-	-	L-2. Core samples	Ce 145

Method of construction
- A Power augered
- Cd Core drilled
- Dc Cable tool
- Dr Hydraulic rotary
- J Jetted

Principal water-bearing unit
- Sa Salisbury aquifer
- M Miocene deposits, undifferentiated
- Mk Manokin aquifer

Water level
- m Measured

Use
- C Commercial
- D Domestic
- Ind Industrial
- Ins Institutional
- Ir Irrigation
- N Not used
- O Observation
- S Stock
- T Exploratory test hole

Type of pump
- J Jet
- N None
- P Piston
- Sb Submersible
- Su Suction
- T Turbine

Remarks
- A Chemical analysis in table 4
- L Descriptive log in table 3
- L-2 Descriptive log in Md. Geol. Survey Rept. of Inv. No. 2
- L-16 Descriptive log in Md. Dept. of Geology, Mines and Water Resources Bull. 16
- Lg Geophysical log available

Table 2.--Descriptions of wells and test holes referred to in this report--Continued.

Well number Wi-	State permit number	Owner or name	Driller	Date completed	Altitude of land surface (feet)	Method of construction	Depth of well (feet)	Diameter of well (inches)	Depth of bottom of casing or top of screen (feet below land surface)	Total screen length (feet)	Principle waterbearing unit	Water level: Feet below land surface	Water level: Date	Use	Type of pump	Gallons per minute (gpm)	Yield: Duration of test (hrs)	Yield: Drawdown (feet)	Yield: Date	Specific capacity (gpm/foot of drawdown)	Remarks	Well number Wi-
Ce 146	-	Wicomico County	U.S. Geological Survey	1963	18	A-Cd	72	-	-		Sa	16	11/15/63	T	N	-	-	-	-	-	L-2. Core samples.	Ce 146
Ce 147	-	Mardel By-Products Corp.	P. E. White	1963	42	Dr	200	-	-	-	Sa,Mk	18.4^{m}	1/2/64	T	N	-	-	-	-	-	L-2. Nearby well pumped during water-level meas.	Ce 147
Ce 150	-	Wicomico County	Penniman & Browne	1964	43	A-Cd	125	-	-	-	Sa	21	3/20.64	T	N	-	-	-	-	-	L-2. Core samples.	Ce 150
Ce 166	65W16	do.	Ideal Well Drillers	1964	38	Dr	118	-	-	-	Sa	12.7^{m}	7/31/64	T	-	-	-	-	-	-	L-2.	Ce 166
Ce 171	-	Alex Pollitt	Middletown Well Drilling Co.	1964	38	Dr	115	-	-	-	Sa	20.3^{m}	11/16/64	T	N	-	-	-	-	-	L-2. Lg.	Ce 171
Ce 172	-	Lambert Geder	do.	1964	37.9	Dr	122	-	-	-	Sa	17.2^{m}	11/13/64	T	N	-	-	-	-	-	L-2. Lg.	Ce 172
Ce 173	-	Alex Pollitt	do.	1964	40	Dr	200	-	-	-	Sa	19.8	11/12/64	T	N	-	-	-	-	-	L-2. Lg.	Ce 173
Ce 175	-	Larmar Corp.	do.	1964	34	Dr	205	-	-	-	Sa	8.6^{m}	11/16/64	T	N	-	-	-	-	-	L-2. Lg.	Ce 175
Ce 176	-	Andrew Turner	do.	1964	42	Dr	160	-	-	-	Sa	18.7^{m}	11/16/64	T	N	-	-	-	-	-	L-2. Lg.	Ce 176
Ce 177	-	James Mitchell	do.	1964	41	Dr	215	-	-	-	Sa	2.3^{m}	11/17/64	T	N	-	-	-	-	-	L-2. Lg.	Ce 177
Ce 178	-	do.	do.	1964	42	Dr	165	-	-	-	Sa	3.3^{m}	11/17/64	T	N	-	-	-	-	-	L-2. Lg.	Ce 178
Ce 188	66W20	Richard Maddix	Ideal Well Drillers	1965	35	Dr	250	-	-	-	Sa	-	-	T	N	-	-	-	-	-	L, Lg.	Ce 188
Ce 198	Wi67W191	City of Salisbury	Layne-Atlantic Co.	1967	34.6	Dr	199	-	-	-	Sa	-	-	T	N	-	-	-	-	-	Lg. Core samples.	Ce 198
Ce 199	Wi67W191	do.	do.	1967	30.7	Dr	207	-	-	-	Sa	-	-	T	N	-	-	-	-	-	Lg.	Ce 199
Ce 200	Wi67W195	do.	do.	1967	29	Dr	160	26-16	83	80	Sa	10.0^{m}	9/18/67		T	4000	-	24	9/18/67	154	Chemical analysis available. Drilled 302 feet deep.	Ce 200
Ce 201	Wi67W191	do.	do.	1967	21.5	Dr	248	-	-	-	Sa	-	-	T	N	-	-	-	-	-	L, Lg.	Ce 201
Ce 202	Wi67W191	do.	do.	1967	37.9	Dr	202	-	-	-	Sa	-	-	T	N	-	-	-	-	-	Lg.	Ce 202
Ce 203	Wi67W191	do.	do.	1967	34.6	Dr	248	-	-	-	Sa	-	-	T	N	-	-	-	-	-	Lg.	Ce 203
Ce 204	Wi67191	do.	do.	1967	28.5	Dr	119	8-3	109	10	Sa	9.4^{m}	4/27/67	O	T	162	-	3.4	4/27/67	47	Lg. Test-drilled 306 feet deep. Core samples. Chemical analysis available.	Ce 204
Ce 209	Wi67W284	Deer's Head Realty Corp.	Ideal Well Drillers	1967	42.3	Dr	140	2-2	132	8	Sa	23.9^{m}	9/18/67	O	N	-	-	-	-	-	Lg. Test-drilled 207 feet deep.	Ce 209
Ce 210	Wi67W285	City of Salisbury	do.	1967	41.1	Dr	132	4-2	122	10	Sa	21.5^{m}	9/18/67	O	N	-	-	-	-	-	Test-drilled 150 feet deep.	Ce 210

Method of construction
- A Power augered
- Cd Core drilled
- Dc Cable tool
- Dr Hydraulic rotary
- J Jetted

Principal water-bearing unit
- Sa Salisbury aquifer
- M Miocene deposits, undifferentiated
- Mk Manokin aquifer

Water level
- m Measured

Use
- C Commercial
- D Domestic
- Ind Industrial
- Ins Institutional
- Ir Irrigation
- N Not used
- O Observation
- S Stock
- T Exploratory test hole

Type of pump
- J Jet
- N None
- P Piston
- Sb Submersible
- Su Suction
- T Turbine

Remarks
- A Chemical analysis in table 4
- L Descriptive log in table 3
- L-2 Descriptive log in Md. Geol. Survey Rept. of Inv. No. 2
- L-16 Descriptive log in Md. Dept. of Geology, Mines and Water Resources Bull. 16
- Lg Geophysical log available

Table 2.--Descriptions of wells and test holes referred to in this report--Continued.

Well number Wi-	State permit number	Owner or name	Driller	Date completed	Altitude of land surface (feet)	Method of construction	Depth of well (feet)	Diameter of well (inches)	Depth of bottom of casing or top of screen (feet below land surface)	Total screen length (feet)	Principle waterbearing unit	Water level: Feet below land surface	Water level: Date	Use	Type of pump	Gallons per minute (gpm)	Yield: Duration of test (hrs)	Yield: Drawdown (feet)	Yield: Date	Specific capacity (gpm/foot of drawdown)	Remarks	Well number Wi-
Ce 211	Wi67W286	City of Salisbury	Ideal Well Drillers	1967	25.1	Dr	122	4-2	112	10	Sa	3.7m	9/18/67	O	N	-	-	-	-	-	Test-drilled 128 feet deep.	Ce 211
Ce 212	Wi67W287	Deer's Head Realty Corp.	do.	1967	38.3	Dr	175	4-2	165	10	Mk	18.7m	11/17/67	O	N	35	-	5.7	11/17/78	6	Lg. Test-drilled 200 feet deep.	Ce 212
Ce 213	Wi67W288	J. Wm. Brittingham Estate	do.	1967	40.0	Dr	157	4-2	147	10	Sa	20.2m	9/18/67	O	N	-	-	-	-	-	Lg. Test-drilled 260 feet deep.	Ce 213
Ce 214	Wi68W44	Wicomico County	do.	1967	43.9	Dr	115	4-2	105	10	Sa	21.6m	9/18/67	O	N	-	-	-	-	-	Test-drilled 120 feet deep.	Ce 214
Ce 216	Wi67W114	Deer's Head Realty Corp.	M. F. Brittingham	1966	36	Dr	303	-	-	0	-	16	12/11/67	T	N	42	-	-	12/11/67	3	L.	Ce 216
Ce 217	-	Wicomico County	U.S. Geological Survey	5/23/68	44	A	107	4½	-	-	Sa	-	-	T	N	-	-	-	-	-	Lg.	Ce 217
Ce 218	-	do.	do.	5/23/68	44	A	122	4½	-	-	Sa	-	-	T	N	-	-	-	-	-	Lg.	Ce 218
Ce 219	-	do.	do.	5/23/68	43	A	122	4½	-	-	Sa	-	-	T	N	-	-	-	-	-	Lg.	Ce 219
Ce 220	-	do.	do.	5/24/68	47	A	112	4½	-	-	Sa	-	-	T	N	-	-	-	-	-	L, Lg.	Ce 220
Ce 221	-	do.	do.	11/11/68	48	A	128	4½	-	-	Sa	-	-	T	N	-	-	-	-	-	Lg.	Ce 221
Ce 222	-	do.	do.	11/12/68	44	A	128	4½	-	-	Sa	-	-	T	N	-	-	-	-	-	Lg.	Ce 222
Ce 223	-	do.	do.	11/13/68	42	A	138	4½	-	-	Sa	-	-	T	N	-	-	-	-	-	L, Lg.	Ce 223
Ce 224	-	do.	do.	10/7/69	44	A	102	4½	-	-	Sa	-	-	T	N	-	-	-	-	-	Lg.	Ce 224
Ce 225	-	do.	do.	10/16/69	27	A	97	4½	-	-	Sa	-	-	T	N	-	-	-	-	-		Ce 225
Ce 226	-	do.	do.	10/16/69	36	A	102	4½	-	-	Sa	-	-	T	N	-	-	-	-	-		Ce 226
Ce 227	-	do.	do.	9/30/69	47	A	125	4½	-	-	Sa	-	-	T	N	-	-	-	-	-	Lg.	Ce 227
Ce 228	-	do.	do.	10/1/69	46	A	117	4½	-	-	Sa	-	-	T	N	-	-	-	-	-	Lg.	Ce 228
Ce 229	-	do.	do.	10/1/69	45	A	112	4½	-	-	Sa	-	-	T	N	-	-	-	-	-	Lg.	Ce 229
Ce 230	-	do.	do.	10/2/69	44	A	117	4½	-	-	Sa	-	-	T	N	-	-	-	-	-	L, Lg.	Ce 230

Method of construction
- A Power augered
- Cd Core drilled
- Dc Cable tool
- Dr Hydraulic rotary
- J Jetted

Principal water-bearing unit
- Sa Salisbury aquifer
- M Miocene deposits, undifferentiated
- Mk Manokin aquifer

Water level
- m Measured

Use
- C Commercial
- D Domestic
- Ind Industrial
- Ins Institutional
- Ir Irrigation
- N Not used
- O Observation
- S Stock
- T Exploratory test hole

Type of pump
- J Jet
- N None
- P Piston
- Sb Submersible
- Su Suction
- T Turbine

Remarks
- A Chemical analysis in table 4
- L Descriptive log in table 3
- L-2 Descriptive log in Md. Geol. Survey Rept. of Inv. No. 2
- L-16 Descriptive log in Md. Dept. of Geology, Mines and Water Resources Bull. 16
- Lg Geophysical log available

Table 2.--Descriptions of wells and test holes referred to in this report--Continued.

Well number	State permit number	Owner or name	Driller	Date completed	Altitude of land surface (feet)	Method of construction	Depth of well (feet)	Diameter of well (inches)	Depth of bottom of casing or top of screen (feet below land surface)	Total screen length (feet)	Principle waterbearing unit	Water level: Feet below land surface	Water level: Date	Use	Type of pump	Gallons per minute (gpm)	Yield: Duration of test (hrs)	Yield: Drawdown (feet)	Yield: Date	Specific capacity (gpm/foot of drawdown)	Remarks	Well number
Cf 81	46375	Holiday Inn	N. M. Shannahan	1962	44	Dr	96	6	86	10	Sa	15.1m	9/12/63	C	Sb	36	4	2	4/11/62	18.0	L-2. Drilled 118 feet deep.	Cf 81
Cf 87	48316	Floyd Catlin	E. R. Kauffman	1962	38	Dr	90	2	76	14	Sa	15	8/7/62	D	J	30	3	10	8/7/62	3.0	L-2.	Cf 87
Cf 125	-	Wicomico County	U.S. Geological Survey	1963	38	A-Cd	102	-	-	-	Sa	19	11/13/63	T	N	-	-	-	-	-	L-2. Core samples.	Cf 125
Cf 126	-	do.	do.	1963	44	A-Cd	102	-	-	-	Sa	13	11/14/63	T	N	-	-	-	-	-	L-2. do.	Cf 126
Cf 128	20849	Eastern Shore Public Service Co.	N. M. Shannahan	1955	42	Dr	109	6	99	10	Sa	16	10/7/55	C	T	40	10	4	10/7/55	10.0	L-2. Report Fe = 45 ppm; ppt = 7.2; Cl = 12 ppm; CO_2 = 4 ppm.	Cf 128
Cf 131	25889	do.	do.	1957	44	Dr	143	16-10	90	53	Sa	20	9/5/57	Ind	N	690	4	14	9/5/57	49.3	L-2. Drilled 175 feet deep. Used as recharge well.	Cf 131
Cf 132	-	W. F. Allen Co.	Boggs Concrete Co.	1964	42	Dr	225	-	-	-	Sa,Mk	14	2/11/64	T	N	-	-	-	-	-	L-2.	Cf 132
Cf 133	Wi65W5	do.	E. R. Kauffman	1964	40	Dr	99	13-6	19	80	Sa	15	7/10/64	Ir	Sb	60	4	3	7/10/64	20.0	Drilled 120 feet deep.	Cf 133
Cf 135	-	do.	Penniman & Browne	1964	25	A-Cd	97	-	-	-	Sa	3	3/20/64	T	N	-	-	-	-	-	L-2. Core samples.	Cf 135
Cf 136	-	A. W. Perdue & Son, Inc.	do.	1964	47	A-Cd	125	-	-	-	Sa	12	3/30/64	T	N	-	-	-	-	-	L-2. do.	Cf 136
Cf 147	-	W. F. Allen Co.	Middletown Well Drilling Co.	1964	41	Dr	80	2	60	20	Sa	16.9m	9/18/67	O	N	-	-	-	-	-	L. Lg. Well drilled to 280 feet.	Cf 147
Cf 148	-	do.	do.	1964	39	Dr	105	-	-	-	Sa	16.8m	11/12/64	T	N	-	-	-	-	-	L, Lg.	Cf 148
Cf 149	-	do.	do.	1964	40	Dr	120	-	-	-	Sa	17.7m	11/12/64	T	N	-	-	-	-	-	L, Lg.	Cf 149
Cf 150	-	Henny Penny Farm	do.	1964	35	Dr	265	-	-	-	Sa	12.4m	11/16/64	T	N	-	-	-	-	-	L, Lg.	Cf 150
Cf 151	-	Gaither Aydelotte	do.	1964	46	Dr	115	-	-	-	Sa	26.1m	11/16/64	T	N	-	-	-	-	-	L, Lg.	Cf 151
Cf 152	-	W. F. Allen Co.	do.	1964	42	Dr	125	-	-	-	Sa	14.7m	11/17/64	T	N	-	-	-	-	-	L-2. Lg.	Cf 152
Cf 161	-	Wicomico County	U.S. Geological Survey	5/14/68	45	A	122	4½	-	-	Sa	-	-	T	N	-	-	-	-	-	Lg.	Cf 161
Cf 162	-	do.	do.	5/15/68	50	A	122	4½	-	-	Sa	-	-	T	N	-	-	-	-	-	Lg.	Cf 162
Cf 163	-	do.	do.	5/15/68	52	A	122	4½	-	-	Sa	-	-	T	N	-	-	-	-	-	Lg.	Cf 163
Cf 164	-	do.	do.	5/15/68	52	A	122	4½	-	-	Sa	-	-	T	N	-	-	-	-	-	Lg.	Cf 164
Cf 165	-	do.	do.	5/16/68	50	A	122	4½	-	-	Sa	-	-	T	N	-	-	-	-	-	Lg.	Cf 165

Method of construction
- A Power augered
- Cd Core drilled
- Dc Cable tool
- Dr Hydraulic rotary
- J Jetted

Principal water-bearing unit
- Sa Salisbury aquifer
- M Miocene deposits, undifferentiated
- Mk Manokin aquifer

Water level
- m Measured

Use
- C Commercial
- D Domestic
- Ind Industrial
- Ins Institutional
- Ir Irrigation
- N Not used
- O Observation
- S Stock
- T Exploratory test hole

Type of pump
- J Jet
- N None
- P Piston
- Sb Submersible
- Su Suction
- T Turbine

Remarks
- A Chemical analysis in table 4
- L Descriptive log in table 3
- L-2 Descriptive log in Md. Geol. Survey Rept. of Inv. No. 2
- L-16 Descriptive log in Md. Dept. of Geology, Mines and Water Resources Bull. 16
- Lg Geophysical log available

Table 2.--Descriptions of wells and test holes referred to in this report--Continued.

Well number	State permit number	Owner or name	Driller	Date completed	Altitude of land surface (feet)	Method of construction	Depth of well (feet)	Diameter of well (inches)	Depth of bottom of casing or top of screen (feet below land surface)	Total screen length (feet)	Principle waterbearing unit	Water level: Feet below land surface	Water level: Date	Use	Type of pump	Gallons per minute (gpm)	Yield: Duration of test (hrs)	Yield: Drawdown (feet)	Yield: Date	Specific capacity (gpm/foot of drawdown)	Remarks	Well number
Cf 166	-	Wicomico County	U.S. Geological Survey	5/16/68	49	A	120	4½	-	-	Sa	-	-	T	N	-	-	-	-	-	Lg.	Cf 166
Cf 167	-	do.	do.	5/17/68	50	A	122	4½	-	-	Sa	-	-	T	N	-	-	-	-	-	Lg.	Cf 167
Cf 168	-	do.	do.	5/21/68	45	A	122	4½	-	-	Sa	-	-	T	N	-	-	-	-	-	Lg.	Cf 168
Cf 169	-	Baysinger Trailer Court	do.	5/21/68	44	A	122	4½	-	-	Sa	-	-	T	N	-	-	-	-	-	Lg.	Cf 169
Cf 170	-	Jane Trescott	do.	5/22/68	44	A	122	4½	-	-	Sa	-	-	T	N	-	-	-	-	-	Lg.	Cf 170
Cf 171	-	do.	do.	5/22/68	43	A	122	4½	-	-	Sa	-	-	T	N	-	-	-	-	-	Lg.	Cf 171
Cf 172	-	do.	do.	11/23/68	44	A	143	4½	-	-	Sa	-	-	T	N	-	-	-	-	-	Lg.	Cf 172
Cf 173	-	N. A. Wilbur	do.	11/25/68	47	A	148	4½	-	-	Sa	-	-	T	N	-	-	-	-	-	Lg.	Cf 173
Cf 174	-	R. P. Cannon	do.	11/26/68	43	A	133	4½	-	-	Sa	-	-	T	N	-	-	-	-	-	Lg.	Cf 174
Cf 175	-	Maryland State Roads Commission	do.	11/26/68	44	A	138	4½	-	-	Sa	-	-	T	N	-	-	-	-	-	Lg.	Cf 174
Cf 176	-	E. D. Sherman	do.	11/26/68	44	A	138	4½	-	-	Sa	-		T	N	-	-	-	-	-	Lg.	Cf 175
Cf 177	Wi67W24	Eastern Shore Public Service Corp.	Ideal Well Drillers	10/3/67	43	Dr	140	12	20	120	Sa	17	10/3/67	N	N	500	8	33	10/3/67	15.1	Lg. Drilled 145 feet deep. Abandoned recharge well.	Cf 177
Cf 178	Wi68W158	Baysinger Trailer Court	Delmarva Drilling Co.	1968	43	Dr	175	2	165	10	Mk	14	6/5/68	D	-	50	2½	11	6/5/68	4.5	Lg. Report water "irony".	Cf 178
Cf 179	Wi690098	W. F. Allen Co.	George Kelley	4/1/69	39	Dr	103	17	-	-	Sa	15	4/1/69	Ir	T	1200	2	25	4/1/69	48	Cement casing, alternating with screen 4-96 deep.	Cf 179
Cf 180	Wi700004	Thomas Brittingham	M. P. Brittingham	12/30/69	41	J	61	2	55	6	Sa	15	12/30/69	D	J	25	3	13	12/30/69	1.9	Drilled 78 feet deep.	Cf 180
Cf 181	-	-	U.S. Geological Survey	10/16/69	43	A	150	4½	-	-	Sa	-	-	T	N	-	-	-	-	-	Lg.	Cf 181
Cf 182	-	Delmarva Power & Light Co.	Ideal Well Drillers	1968	43	Dr	147	12	-	-	Sa	19.5m	6/13/68	-	-	-	-	-	-	-	Lg. Recharge well; began use about 4/1/70.	Cf 182
Cf 183	Wi67W111	Peninsula Nurseries	do.	12/3/66	43	Dr	110	4	100	10	Sa	20	12/3/66	Ir	-	15	2	10½	12/3/66	1.4	Drilled 120 feet deep.	Cf 183

Method of construction
- A Power augered
- Cd Core drilled
- Dc Cable tool
- Dr Hydraulic rotary
- J Jetted

Principal water-bearing unit
- Sa Salisbury aquifer
- M Miocene deposits, undifferentiated
- Mk Manokin aquifer

Water level
- m Measured

Use
- C Commercial
- D Domestic
- Ind Industrial
- Ins Institutional
- Ir Irrigation
- N Not used
- O Observation
- S Stock
- T Exploratory test hole

Type of pump
- J Jet
- N None
- P Piston
- Sb Submersible
- Su Suction
- T Turbine

Remarks
- A Chemical analysis in table 4
- L Descriptive log in table 3
- L-2 Descriptive log in Md. Geol. Survey Rept. of Inv. No. 2
- L-16 Descriptive log in Md. Dapt. of Geology, Mines and Water Resources Bull. 16
- Lg Geophysical log available

Table 3.--Logs of wells and test holes referred to in this report.

	Thickness (feet)	Depth (feet)
Wi-Bd 51 Altitude: 38 feet		
Owner: Wicomico County		
Pleistocene deposits:		
Walston Silt:		
Sand, clayey, yellow-orange-brown........	8	8
Salisbury aquifer (undifferentiated):		
Sand, medium to coarse, sharp, tan.......	10	18
Gravel, fine, and coarse sand............	2	20
Sand, coarse, and fine gravel, reddish-orange-brown..........................	18	38
Gravel and sand, orange-brown............	5	43
Sand, medium to fine, becoming finer downward; yellow-brown (clay from 64 to 69 feet may be "mucky", with dark blue-gray metallic sheen).........	39	82
Miocene deposits:		
Yorktown Formation (?):		
Clay, blue-gray (clay may be in part "mucky", with dark blue-gray metallic sheen)................................	20	102
Sand, medium to coarse, dark blue-gray...	31	133
Wi-Bd 52 Altitude: 32 feet		
Owner: Wicomico County		
Pleistocene deposits:		
Walston Silt:		
Clay, sandy, tan.........................	3	3
Salisbury aquifer (undifferentiated):		
Sand, coarse to very coarse, gray, saturated	9	12
Sand, coarse, and some fine sand; brown..	6	18
Gravelly sand............................	2	20
Sand, coarse to very coarse, and interbeds of pebbly sand; pumpkin-colored...	60	80
Sand, coarse to very coarse, and fine to medium gravel, orange-brown; beds of sand from 86 to 90 feet and 10 to 114 feet.................................	42	122

Table 3.--Logs of wells and test holes referred to in this report--Continued

	Thickness (feet)	Depth (feet)
Miocene deposits:		
Yorktown Formation (?):		
Clay, dark gray, medium stiff, slick.....	8	130
Sand, fine to medium, silty; dark blue-gray..............................	3	133
Wi-Be 36 Altitude: 50 feet		
Owner: Wicomico County		
Pleistocene deposits:		
Walston Silt:		
Sand, poorly-sorted, a little clayey; chocolate-brown and tan gray...........	3	3
Clay, coarse-to-medium sandy, tan to yellow-gray; sticky below 8 feet.......	10	13
Salisbury aquifer (undifferentiated):		
Sand, fine to very coarse, sharp, light gray; "soupy" returns.................	10	23
Sand, coarse, sharp, light-gray..........	12	35
Sand, medium to coarse...................	13	48
Sand, fine...............................	3	51
Sand, interbedded coarse and medium; light yellow-brown.....................	15	66
Sand, medium to coarse, orange............	22	88
Sand, coarse to very coarse, sharp, orange................................	8	98
Miocene deposits:		
Yorktown Formation (?):		
Clay, dark gray becoming dark blue downward..............................	22	118
Sand, medium to coarse, sharp, pink or brick colored.........................	15	133
Wi-Be 37 Altitude: 49 feet		
Owner: Wicomico County		
Pleistocene deposits:		
Walston Silt:		
Loam, sandy, dark-brown; and fine, gritty, yellow-brown-gray sand.................	3	3

Table 3.--Logs of wells and test holes referred to in this report--Continued

	Thickness (feet)	Depth (feet)
Clay, sandy, plastic, yellow-brown-gray changing abruptly to light gray (streaked with iron oxide)...........	20	23
Salisbury aquifer (undifferentiated):		
Sand, coarse, yellow-gray................	25	48
Sand, coarse to very coarse, sharp.......	10	58
Sand, very coarse, sharp, and small to medium pebbles; shell fragments........	10	68
Sand, medium to coarse, interbedded with pebbly coarse sand; yellow-brown to orange-brown.........................	30	98
Miocene deposits:		
Yorktown Formation (?):		
Clay, dark blue-gray, plastic-stiff, smooth...............................	10	108
Sand, medium to fine, dark blue-gray.....	9	117
Clay and fine sand interbedded. Dark blue-gray............................	16	133

Wi-Be 40 Altitude: 44 feet
Owner: Wicomico County

	Thickness (feet)	Depth (feet)
Pleistocene deposits:		
Walston Silt:		
Clay, sandy; dark brown above and orange, gray, and tan below...................	8	8
Salisbury aquifer (undifferentiated):		
Sand, pebbly, light yellow-brown.........	5	13
Sand, medium to very coarse; interbeds containing fine gravel and coarse sand. Tan-gray above, to red-orange below....	54	67
Sand, coarse, and fine gravel; including medium to coarse sub-angular pebbles...	5	72
Clay (including very soft, dark blue-gray) and sand, interbedded. (medium to coarse pebbles also included?)...............	28	100
Miocene deposits:		
Yorktown Formation (?):		
Clay, tight, dark blue-gray.............	8	108
Sand, fine; bottom 2 feet black-brown....	5	113

Table 3.--Logs of wells and test holes referred to in this report--Continued

	Thickness (feet)	Depth (feet)
Wi-Be 41 Altitude: 55 feet		
Owner: Wicomico County		
Pleistocene deposits:		
Walston Silt:		
Silty, sandy, light brown.................	8	8
Sand, fine, tan gray......................	7	15
Salisbury aquifer (undifferentiated):		
Sand, coarse, and fine to medium gravel; yellow-rusty color.....................	20	35
Sand, fine, yellow-gray...................	5	40
Sand, coarse, and fine to medium gravel; light yellow-brown.....................	35	75
Sand, light yellow-brown, coarser downward..................................	10	85
Gravel, fine, and coarse sand; brown-gray; clean; cobbles(?) at 87 ft.......	20	105
Sand, coarse, brown-gray..................	10	115
Sand, coarse, and fine gravel; brown-gray	5	120
Sand, coarse and fine; brown-gray........	30	150
Sand, fine to medium; gray-brown.........	5	155
Sand, medium to coarse, yellow-brown-gray, and mica flakes..................	5	160
(Sand, coarse, tan-gray)?................	15	175
(Sand, coarse, dark yellow-brown)?.......	5	180
(Sand, coarse, and gravel; some iron-cementation)?.........................	10	190
(Sand, fine and coarse, stratified, and some beds iron-cemented)?............	10	200
Gravel, fine, and some coarse pebbles or cobbles; layers of iron-cemented gravel at 208 and 213 ft.....................	20	220
Miocene deposits:		
St. Marys Formation:		
Clay and some fine sand; dark blue-gray. Black "wood" fragments.................	10	230
Clay, sandy, shells, dark gray; slow drilling................................	20	250
"Hardpan": lime-cemented shells; very hard drilling.........................	3	253
Clay, gritty, dark gray, shells; easy drilling................................	7	260

Table 3.--Logs of wells and test holes referred to in this report--Continued

	Thickness (feet)	Depth (feet)
Wi-Be 42 Altitude: 48 feet		
Owner: Wicomico County		
Pleistocene deposits:		
Walston Silt:		
Clay, silty and sandy; yellow-brown......	13	13
Salisbury aquifer (undifferentiated):		
Sand and pebbles; yellow-brown...........	3	16
Sand, coarse-to-very coarse, and very fine gravel; yellow-brown..............	24	40
Sand, coarse and very fine gravel; yellow-orange brown...................	12	52
Sand, coarse-to-very coarse, and fine-to-medium gravel; yellow-orange brown..	8	60
Sand, coarse, and fine gravel; light yellow-brown..........................	10	70
Sand, fine to coarse, and interbeds of fine gravel; tan-gray.................	15	85
Gravel, fine, sharp, clean; brown-gray...	15	100
Sand, coarse, and fine gravel; brown-gray.................................	10	110
Sand, fine-to-coarse; and sharp, fine pebbles; brown-gray....................	17	117
Sand, very coarse, and fine-to-medium gravel, brown-gray; cleaner toward base.................................	23	140
(Reworked Miocene deposits?):		
Sand, coarse-to-fine, and very fine gravel. Gray to dark gray(?)..........	4	144
Interbedded sticky, dark gray clay, and fine sand (and silt?)................	10	154
Sand, coarse-to-very coarse, and very fine gravel; mostly clear, gray, and smoky quartz, and about 10 percent hard black grains. Returns were dirty green-brown gray, but true color of material was probably tan-gray. Water confined: flowed out top of drillstem, above sand surface, from depth of 160 feet	12	166

Table 3.--Logs of wells and test holes referred to in this report--Continued

	Thickness (feet)	Depth (feet)
Miocene deposits		
Yorktown Formation (?):		
Manokin aquifer:		
Sand, fine-to-medium; dark gray..........	19	185
St. Marys Formation:		
Clay and fine sand, alternately; silty, dark-speckled; dark gray. Shell fragments	15	200
Sand, fine (finer with increasing depth), dark gray; shell fragments............	20	220
Clay and fine sand, interbedded; dark gray; small shells and shell fragments.	20	240
Clay, stiff, dark gray, and shells (shell bed 250-251 ft; Turritella included)...	17	257
Clay (drilled like "straight blue clay").	3	260
Wi-Be 43 Altitude: 44 feet		
Owner: Wicomico County		
Pleistocene deposits:		
Walston Silt:		
Clay, fine-sandy, yellow-gray..........	8	8
Salisbury aquifer (undifferentiated):		
Sand, coarse, and pebbles; stringers of fine sand. Gray-brown................	27	35
Sand, coarse, and fine gravel; tan-gray..	25	60
Sand, coarse, and fine gravel, with interbedded fine sand; tan-gray........	30	90
Gravel, fine; pebbles are angular........	15	105
Sand, coarse to very coarse, and pebbles; brown-gray; shiny black grains common..	35	140
Sand, coarse; yellow brown-gray..........	12	152
Sand, coarse to-medium, light yellow-brown gray............................	5	157
Sand, medium-to-coarse, light yellow-brown-gray............................	13	170
Miocene deposits:		
Yorktown Formation (?):		
Manokin aquifer:		
Clay, "heavy", dark blue-gray...........	1	171

Table 3.--Logs of wells and test holes referred to in this report--Continued

	Thickness (feet)	Depth (feet)
Sand, dark gray, coarse above and fine below. Black wood and hard black mineral grains........................	9	180
Clay, dark..............................	15	195
Sand, coarse, and fine gravel...........	5	200
Wi-Be 46 Altitude: 50 feet		
Owner: Wicomico County		
Pleistocene deposits:		
Walston Silt:		
Loam, fine-sandy, dark brown.............	2	2
Clay, sandy, khaki colored..............	5	7
Clay, fine-to-medium sandy, light gray...	5	12
Salisbury aquifer (undifferentiated):		
Sand, fine to medium, gritty, "runny" or "soupy", tan-gray.....................	28	40
Sand, medium to coarse, "thin", "runny"; tan-gray changing downward to pink-red	20	60
Sand, coarse and very coarse, and fine to very fine gravel. Orange-red brown..	20	80
Sand, coarse to very coarse, and fine to very fine gravel; dark pumpkin color...	20	100
Miocene deposits:		
Yorktown Formation (?):		
Clay, plastic, lead-gray.................	18	118
Sand, medium to fine, dark blue-gray.....	14	132
Wi-Bf 50 Altitude: 45 feet		
Owner: Wicomico County		
Holocene deposits:		
Sand, fine to medium, yellow-brown.......	2	2
Pleistocene deposits:		
Salisbury aquifer (undifferentiated):		
Sand, fine to medium, coarsening downward to fine to very coarse sand and very fine gravel; tán-gray.............	20	22

Table 3.--Logs of wells and test holes referred to in this report--Continued

	Thickness (feet)	Depth (feet)
Sand, very coarse; light gray............	13	35
Sand, a little finer....................	7	42
Sand, coarse to very coarse, and fine to very fine gravel; yellow-brown-gray....	62	104
Miocene deposits:		
Yorktown Formation (?):		
Clay, fine-sandy, sticky, dark blue-gray.	12	116
Sand..................................	4	120
Clay, including a black, subrounded pebble 1/2 x 3/4 inch.................	2	122

<u>Wi-Bf 57</u> Altitude: 30 feet
Owner: Donald Wilbur

	Thickness (feet)	Depth (feet)
Pleistocene deposits:		
Salisbury aquifer (undifferentiated):		
Sand, fine, gritty, tan-gray.............	2	2
Sand, fine and medium interbedded; yellow-brown................................	28	30
Sand, coarse, yellow-brown...............	9	39
Sand, coarse to very coarse, yellow-brown	28	67
Sand, fine (?)..........................	8	75
Sand, coarse............................	7	82
Miocene deposits:		
Yorktown Formation (?):		
Clay, stiffish, slick; dark blue-gray, and maroon (burgundy)..................	7	89
Sand, fine, and silty clay interbedded; dark blue-gray (thin bed of whitish coarse-sandy soft clay near 90 or 95 feet)................................	10	99
Sand, medium to coarse, blue-gray........	3	102
Sand, medium to coarse, peaty, chocolate-brown................................	2	104
Sand, medium to coarse, clean, gray......	3	107

Table 3.--Logs of wells and test holes referred to in this report--Continued

	Thickness (feet)	Depth (feet)
Wi-Ce 188 Altitude: 35 feet		
Owner: Richard Maddix		
Holocene deposits:		
Sand, fine, tan	10	10
Pleistocene deposits:		
Salisbury aquifer (undifferentiated):		
Sand, fine, tan-white	10	20
Sand, fine-medium, white	10	30
Sand, medium-coarse, tan	10	40
Sand, medium-coarse, tan	10	50
Sand, coarse, iron-stained (some gravel).	14	64
Sand, very coarse, rusty tan; gravel	11	75
Gravel, mostly white	5	80
Sand, coarse, tan; some gravel	12	92
Gravel, mostly white	8	100
Sand, coarse, tan; gravelly	7	107
Gravel and sand, very coarse, tan; few pebbles	13	120
Sand, medium-coarse, tan; gravelly	10	130
Sand, very coarse, tan; gravelly	10	140
Sand, very coarse, tan; some gravel	20	160
Gravel and sand, very coarse; iron stained	10	170
Sand, fine-medium, tan	10	180
Sand, medium-coarse, rusty tan	10	190
Sand, coarse, rusty red; gravelly	10	200
Sand, coarse, tan and gravel	10	210
Sand, very coarse, tan; gravelly	10	220
Sand, medium-coarse, gray-tan	14	234
Miocene deposits (undifferentiated):		
Sand, fine, gray; lignite	6	240
Sand, fine-medium, dark gray; some gray clay	10	250

Table 3.--Logs of wells and test holes referred to in this report--Continued

	Thickness (feet)	Depth (feet)
Wi-Ce 201 Altitude 21 feet		
Owner: City of Salisbury		
Holocene deposits:		
Sand (fill)	1	1
Pleistocene deposits:		
Salisbury aquifer (undifferentiated):		
Sand and layers of clay, white...........	9	10
Sand, medium to coarse, brownish.........	3	13
Sand, coarse, brown; and fine gravel.....	71	84
Sand, coarse, brown; and pea gravel......	69	153
Sand and pea gravel, tan.................	13	166
Sand, coarse, tan; and coarse gravel; with thin layers of reddish clay.......	10	176
Gravel, coarse; and sand with thin layers of soft gray clay......................	10	186
Sand and fine gravel tan; with thin layers of gray clay....................	11	197
Sand, tight-packed, tan; and few streaks of gray clay.........................	8	205
Sand, fine, tan	12	217
Miocene deposits:		
St. Marys Formation:		
Clay, gray, (no sample)	12	229
Clay, gray, and broken fossil shells	19	248
Wi-Ce 216 Altitude: 36 feet		
Owner: Deer's Head Realty Corp.		
Pleistocene deposits:		
Walston Silt:		
Topsoil	2	2
Clay and gravel	3	5
Salisbury aquifer (undifferentiated):		
Gravel and sand, white	7	12
Sand and gravel, yellow	12	24
Sand and gravel, orange	6	30
Clay and sand, yellow	3	33
Sand and gravel, yellow	27	60
Sand and wood	12	72
Sand and gravel, orange	6	78

Table 3.--Logs of wells and test holes referred to in this report--Continued

	Thickness (feet)	Depth (feet)
Miocene deposits:		
Yorktown Formation (?):		
Clay and wood, blue......................	7	85
Sand, fine, and gray clay................	35	120
Clay and sand, green and gray............	10	130
Sand, clay, and wood; gray...............	55	185
Gravel, medium, white, and wood..........	30	215
St. Marys Formation:		
Clay and fine sand, gray.................	88	303
<u>Wi-Ce 220</u> Altitude: 47 feet		
Owner: Wicomico County		
Pleistocene deposits:		
Walston Silt:		
Sand, fine, silty, brown, powdery-dry; above laminated (?) pink, stiff clav and light-gray, fine-sandy silt........	2	2
Clay, fine-sandy, silty, stiff, medium-gray................................	5	7
Sand.....................................	2	9
Clay, plastic............................	3	12
Clay, plastic, and sand, tan-gray........	3	15
Salisbury aquifer (undifferentiated):		
Sand, coarse, tan-gray, saturated........	2	17
Sand, very coarse, gravelly, tan-gray, saturated.............................	26	43
Sand, coarse and some fine to very fine gravel................................	9	52
Sand, (medium?)..........................	10	62
Sand, coarse, and very fine gravel, yellow-brown............................	10	72
Interbedded sandy clay, clay, sand, and some gravel............................	24	96
Sand and gravel, and some thin beds of clay. (Black (wood?) streaks and inclusions from 110 to 112 ft).	26 +	122 +

Table 3.--Logs of wells and test holes referred to in this report--Continued

	Thickness (feet)	Depth (feet)
Wi-Ce 223 Altitude: 42 feet		
Owner: Wicomico County		
Pleistocene deposits:		
Walston Silt:		
Loam, medium-coarse, sandy, dark gray-brown	3	3
Sand, silty-clayey, khaki-colored	5	8
Salisbury aquifer (undifferentiated):		
Sand, fine to coarse and gritty; tan-gray; saturated	10	18
Sand, fine to coarse, poorly sorted, tan-gray	27	45
Sand, alternately fine and coarse	41	86
Miocene deposits:		
Yorktown Formation (?):		
Clay, fine-sandy; dark-gray	5	91
Sand, dark gray	7	98
Clay or fine sand, dark-gray	2	100
Sand, fine to medium	4	104
Sand, coarse	12	116
(Sand, fine)?	6	122
Sand, fine and coarse alternating	16	138
Wi-Ce 230 Altitude: 44 feet		
Owner: Wicomico County		
Holocene deposits:		
Sand, brown	2	2
Pleistocene deposits:		
Walston Silt:		
Sand, fine, silty, tan-gray	10	12
Salisbury aquifer (undifferentiated):		
Sand, medium to coarse, light tan-gray	38	50
Sand, medium and coarse, brown-gray and orange-brown; interbeds of orange-brown coarse sand and very-fine gravel	30	80

Table 3.--Logs of wells and test holes referred to in this report--Continued

	Thickness (feet)	Depth (feet)
Clay, silty, fine sandy, very soft, dark gray; interbeds of fine sand......	16	96
Sand....................................	3	99
Miocene deposits (undifferentiated):		
Clay, stiff, dark blue-gray and green-gray, and interbeds of fine, dark blue-gray sand...........................	11	110
Clay, silty, dark blue-gray, of sticky-"yeasty" consistency; and fine, silty sand with medium-dark brown wood.......	7	117

Wi-Cf 147 Altitude: 41 feet
Owner: W. F. Allen Co.

	Thickness (feet)	Depth (feet)
Holocene deposits:		
Top soil................................	1	1
Sand, fine-medium, tan..................	4	5
Pleistocene deposits:		
Walston Silt:		
Clay, tan, sandy........................	5	10
Salisbury aquifer:		
Beaverdam Sand:		
Sand, medium-coarse, tan, silty..........	5	15
Sand, medium-coarse; white pebbles; clayey matrix...............................	5	20
Sand, very fine-fine, white, silty.......	5	25
Sand, medium-coarse, white, silty........	10	35
Sand, medium-coarse, pebbly, tannish-gray	5	40
Sand, medium-coarse, tannish-gray........	8	48
Red gravelly facies:		
Sand, coarse-very coarse, orange-brown; and gravel............................	6	54
Clay, gritty, rusty brown................	4	58
Clay, gray...............................	7	65
Sand, coarse-fine pebbly, orange-brown...	10	75
Sand, very coarse-granular, orange-brown..	15	90
Sand, medium-coarse, tan.................	5	95
Sand, fine-medium, tan...................	10	105
Sand, medium, some granules; tan.........	10	115

Table 3.--Logs of wells and test holes referred to in this report--Continued

	Thickness (feet)	Depth (feet)
Sand, very coarse-fine pebbly, tan.......	15	130
Gravel, very coarse, sandy-granular, tan.	8	138
Sand, medium-coarse, pebbly, tan.........	7	145
Sand, coarse-granular, tan...............	8	153
Gravel, fine, orange-brown...............	7	160
Gravel, fine-medium, orange-brown........	5	165
Sand, medium-coarse, some pebbles; tan...	5	170
Sand, fine-medium, grayish-tan...........	20	190
Sand, medium-coarse, grayish-tan.........	10	200
Sand, coarse-granular, grayish-orange....	7	207
Miocene deposits:		
Yorktown Formation (?):		
Sand, fine-medium, gray..................	3	210
Sand, medium-coarse, gray................	10	220
Sand, very fine, gray....................	10	230
Sand, very fine, gray, lignitic fragments	20	250
Sand, very fine, gray, abundant lignitic fragments..............................	5	255
Sand, very fine, gray....................	3	258
St. Marys Formation:		
Clay, fine sandy, dark gray, shell fragments (e.g. Turritella, Uzita, Terebra)...............................	12	270
Clay, fine, sandy, dark gray, abundant shell fragments.......................	15	285

Wi-Cf 148 Altitude: 39 feet
Owner: W. F. Allen Co.

	Thickness (feet)	Depth (feet)
Holocene deposits:		
Sand, very fine to fine, well-sorted, tannish-brown.........................	5	5
Pleistocene deposits:		
Walston Silt:		
Sand, fine to medium, clayey, grayish-tan..................................	5	10
Salisbury aquifer:		
Beaverdam Sand:		
Sand, medium-coarse, finely-granular, tannish-white.........................	5	15

Table 3.--Logs of wells and test holes referred to in this report--Continued

	Thickness (feet)	Depth (feet)
Sand, medium-coarse, tannish-white; few pebbles	10	25
Red gravelly facies:		
Sand, coarse to fine, orange-brown	5	30
Sand, medium-coarse, pebbly, orange-brown	5	35
Sand, coarse-granular, tan	5	40
Sand, fine-medium, some granules; tan	5	45
Sand, medium-coarse, fine pebbles; orange-brown	5	50
Gravel, very coarse-granular, orange-brown	4	54
Clay, gritty, mottled tan and gray	4	58
Sand, fine silty, tan	7	65
Sand, medium-very coarse, tan	5	70
Sand, fine, tan	5	75
Sand, very fine-fine, grayish-tan	7	82
Sand, medium-very coarse, tan, and gravel	3	85
Sand, fine-medium, grayish-tan	5	90
Miocene deposits (undifferentiated):		
Clay, gritty, dark-gray; intercalated very fine, dark-gray sand	10	100
Sand, very fine, clayey, dark gray; lignitic fragments	5	105

Wi-Cf 149 Altitude: 40 feet
Owner: W. F. Allen Co.

	Thickness (feet)	Depth (feet)
Holocene deposits:		
Sand, very fine-fine, tan	5	5
Pleistocene deposits:		
Walston Silt:		
Clay, very gritty, mottled tan and gray	8	13
Salisbury aquifer (undifferentiated):		
Sand, fine-medium, grayish-white; few pebbles	2	15
Sand, fine-medium, orange-brown	5	20
Sand, fine-medium, grayish-tan	5	25

Table 3.--Logs of wells and test holes referred to in this report--Continued

	Thickness (feet)	Depth (feet)
Sand, medium, orange-brown...............	5	30
Sand, medium-coarse, tan.................	5	35
Sand, fine-medium, gray; abundant black lignitic material.....................	7	42
Sand, coarse-granular, orange-brown; abundant pebbles (1/2 in.).............	3	45
Sand, fine-medium, tan...................	8	53
Sand, coarse, orange-brown; pebbles (1 in.)...............................	2	55
Sand, fine-medium, tan; few pebbles (1 in.)	5	60
Sand, medium, tan to orange-brown........	5	65
Sand, very fine-fine, tan................	5	70
Sand, coarse-granular, orange-brown......	10	80
Sand, coarse-fine pebbly, tan............	15	95
Sand, very coarse-granular, orange-brown; and gravel (1/4-in. pebbles)..........	5	100
Miocene deposits (undifferentiated):		
Clay, gritty, gray; woody fragments......	6	106
Sand, very fine-fine, gray; woody fragments............................	14	120
<u>Wi-Cf 150</u> Altitude: 35 feet		
Owner: Henny Penny Farm		
Holocene deposits:		
Sand, medium, slightly clayey, tan.......	5	5
Pleistocene deposits:		
Walston Silt:		
Clay, gritty, grayish..........................	5	10
Salisbury aquifer:		
Beaverdam Sand:		
Sand, fine-medium, grayish-tan; some fine pebbles..........................	5	15
Sand, fine-medium, grayish-white.........	5	20
Sand, very coarse-coarse, grayish-white; some fine pebbles.....................	5	25
Sand, medium-coarse, grayish-white.......	5	30
Sand, medium-coarse, tannish-gray........	5	35

Table 3.--Logs of wells and test holes referred to in this report--Continuous

	Thickness (feet)	Depth (feet)
Red gravelly facies:		
Sand, coarse-granular, tan; lignitic fragments	6	41
Gravel, fine-medium, tan, in matrix of rusty-brown clay	2	43
Clay, gritty, tan	3	46
Clay, gritty, gray	15	61
Sand, coarse-granular, orange-brown	4	65
Sand, coarse-very coarse, granular, tan	5	70
Sand, very coarse, grayish tan; and fine gravel	5	75
Sand, coarse-very coarse, granular, tannish-gray	20	95
Sand, medium, grayish-tan	5	100
Sand, very coarse-fine pebbly, grayish-tan	10	110
Sand, very coarse, granular, tan	5	115
Sand, coarse-very coarse, tan	5	120
Gravel, fine-medium, orange-brown, very coarse sandy matrix	5	125
Gravel, fine-coarse, orange-brown, in sandy matrix	10	135
Sand, coarse-very coarse, orange-brown; and gravel	10	145
Sand, medium, orange-brown	5	150
Sand, fine-medium, grayish-tan	10	160
Sand, fine, grayish-tan	5	165
Sand, medium-coarse, tan; and gravel, fine	10	175
Sand, coarse-very coarse, orange-brown	5	180
Sand, very coarse-fine pebbly; orange-brown	5	185
Gravel, fine, orange-brown	5	190
Sand, very coarse, orange-brown, and gravel, fine; ferruginous laminae, rusty, brown	5	195

Table 3.--Logs of wells and test holes referred to in this report--Continuous

	Thickness (feet)	Depth (feet)
Concretion zone, fragmented ferruginous material, rusty-brown..................	5	200
Sand, coarse, very coarse, rusty-brown...	5	205
Sand, fine, grayish-tan..................	5	210
Sand, medium, grayish-tan................	5	215
Sand, fine, grayish-tan..................	5	220
Sand, medium, grayish-tan................	5	225
Sand, fine, tannish-gray.................	5	230
Miocene deposits:		
Yorktown Formation (?):		
Sand, very fine-fine, dark gray..........	6	236
St. Marys Formation:		
Clay, gritty, dark gray..................	19	255
Clay, gritty, dark gray, shell fragments (_Turritella_, _Terebra_, pelecypod fragments).............................	10	265

_Wi-Cf 151_ Altitude: 46 feet
Owner: Gaither Aydelotte
Note: Test hole drilled in borrow pit. Pit floor (well datum) is about 4 ft. below former land surface.

	Thickness (feet)	Depth (feet)
Holocene material in wall of pit is tannish-gray, fine sand.		
Pleistocene deposits:		
Walston Silt:		
Sand, fine, clayey, tan..................	5	5
Sand, fine, very clayey, tan.............	3	8
Salisbury aquifer (undifferentiated):		
Sand, medium-coarse, white...............	7	15
Sand, medium, some fine pebbles; tan.....	5	20
Sand, medium, tan........................	10	30
Sand, coarse-very coarse, pebbly, orange-brown................................	5	35
Sand, very coarse-granular, tan..........	9	44
Sand, medium-coarse, orange-brown........	1	45

Table 3. Logs of wells and test holes referred to in this report--Continued

	Thickness (feet)	Depth (feet)
Gravel, medium-coarse; clay matrix.......	1	46
Clay, orange-brown.......................	2	48
Clay, gritty, dark gray..................	12	60
Sand, fine-medium, rusty-brown, ferruginous fragments (concretions)............	5	65
Sand, coarse granular, tan...............	5	70
Gravel, medium-coarse, grayish-tan.......	5	75
Sand, medium-coarse, tan.................	10	85
Sand, coarse-fine pebbly, orange-brown...	12	97
Miocene deposits:		
Yorktown Formation (?):		
Clay, gritty, dark gray..........................	8	105
Sand, very fine-fine, dark gray; lignitic fragments..................................	10	115

TABLE 4. Chemical analyses of ground water collected during this study.

(Chemical constituents in milligrams per liter. Analyses by U. S. Geological Survey)

U.S.G.S. well number	Geologic unit	Date of collection	Temperature (°C)	Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Zinc (Zn)	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$		Specific conductance (micromhos at 25°C)	pH	Color
																		Calcium, magnesium	Noncarbonate			
Wi-Be 46	Salisbury aquifer	10/22/69	17	27	1.5	0.25	2.7	0.8	5.9	2.5	0	13	5.3	0.0	8.7	0.07	76	10	11	65	4.5	1
Wi-Be 47	Salisbury aquifer	10/22/69	18	15	.01	.01	8.6	5.1	5.6	4.2	2	.2	13	.0	53	.20	117	43	42	151	6.0	0

Available from

MARYLAND GEOLOGICAL SURVEY

The Johns Hopkins University

Baltimore, Maryland 21218

Price: $5.50

Md. Sales Tax—4%

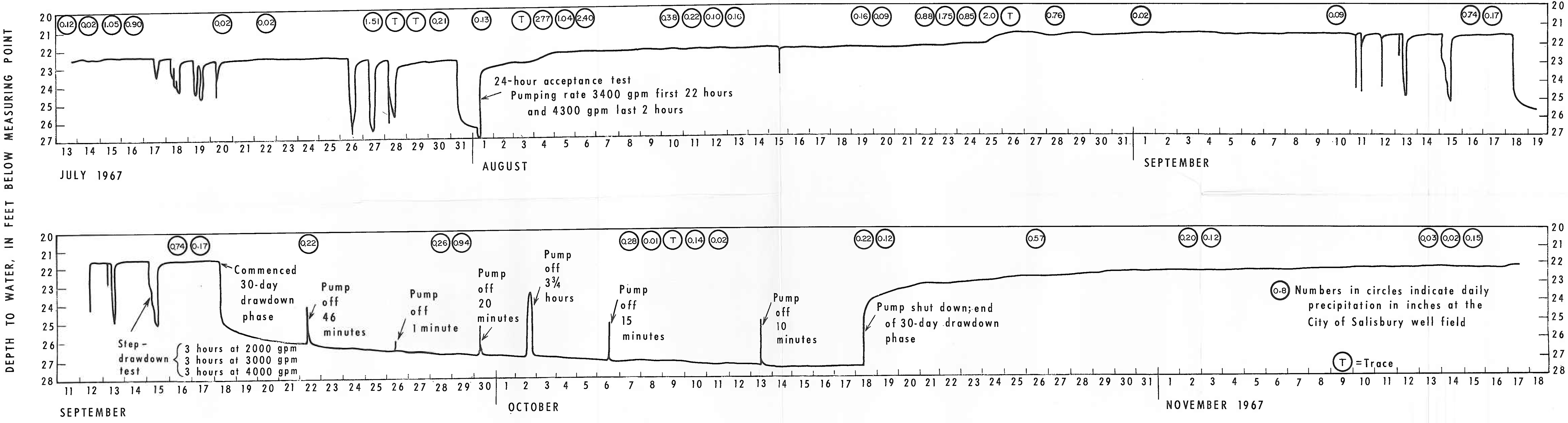


Figure 13. (Part 1). Hydrograph of observation well Wi-Ce 210 showing the continuous record of water levels during pre-pumping, pumping, and recovery phases of the test.

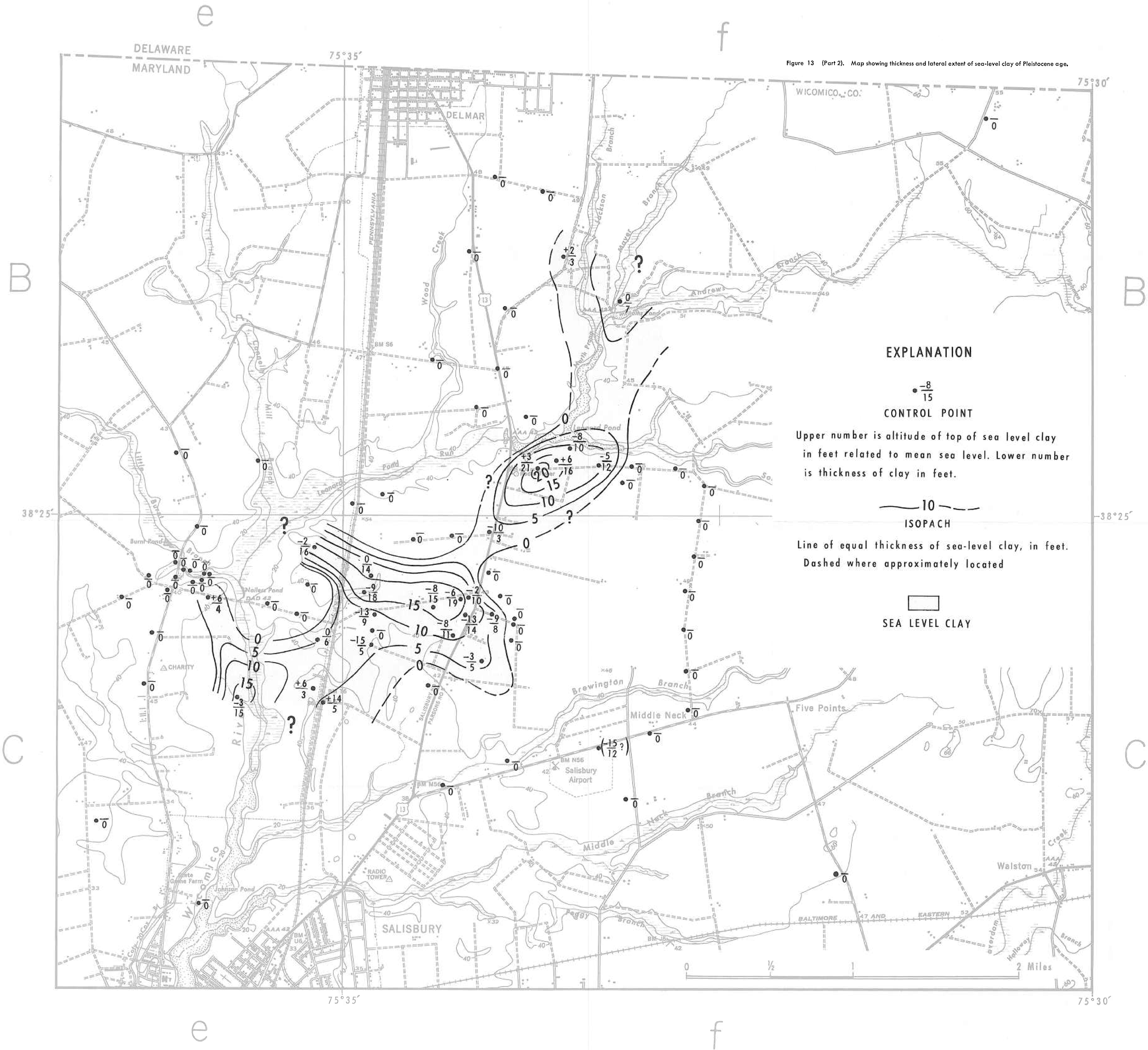


Figure 13 (Part 2). Map showing thickness and lateral extent of sea-level clay of Pleistocene age.